VOLUME XXV NUMBER 5

BOTANICAL GAZETTE

MAY 1898

THE ORIENTATION OF THE PLANT EGG AND ITS ECOLOGICAL SIGNIFICANCE.

CONWAY MACMILLAN.

As a convenient series of forms in which the embryogeny has been carefully investigated one may select the Archegoniatæ. A number of groups in which genuine eggs are developed thus fall outside the limits of discussion. Among these are the Chlorophyceæ with such genera as Sphæroplea and Coleochæte; the Phæophyceæ, particularly Fucus and its allies; and the Phycomycetes, as for example Peronospora and Achlya. The metaspermic types of segmentation will be found to be derived from certain archegoniate types and will receive incidental attention, but it will be quite unnecessary to enter into an examination of the modified and often degenerate processes that succeed the physiological equivalent of fecundation in Rhodophyceæ. With such limitations there will be presented a review, in succinct form, of certain important types of egg segmentation known to occur among the plants classified by Engler as *Embryophyta zoidiogama*.

BRYOPHYTIC ORIENTATION AND SEGMENTATION TYPES.

Among bryophytes the egg manifests in the Hepaticæ all the types of segmentation that are retained in the higher order. Therefore it will be unnecessary to give any special account for the Musci. Essentially all Musci present segmentations that are

ecologically equivalent, with the possible exception of Archidium which seems to be a degenerate type rather than rudimentary. The basal type among Musci seems to be that of Sphagnum, which connects closely with the type of Anthoceros among Hepaticæ. In mosses the most important improvement over Hepaticæ, in the embryogeny, is the early differentiation of at least the distal cell of the embryo as an apical cell, while in some cases the proximal cell also accepts this character and organizes the foot by apical segmentations. In Hepaticæ the distal apical cell is the only apical cell developed, and this does not undergo improvement beyond the hemispherical type, so that apical growth in the hepatic embryo is limited.

Embryogeny of Riccia.— Early researches upon the embryogeny of *Riccia glauca* were conducted by Hofmeister,[1] whose account, however, was quite imperfect. His figure (*l. c. pl. 10, fig. 9*) shows a rather abnormally inclined basal wall. Our exact knowledge of the early stages in this embryogeny are due to Kienitz-Gerloff,[2] who corrected the errors in the original account of Hofmeister and figured the early stages (*l. c. pl. 3*) from the primitive segmentation to the specialization of amphithecium and endothecium. Leitgeb[3] considered the embryogeny of this plant and shows (*l. c. pl. 2, fig. 8*) an early stage in the embryogeny with the normal slightly inclined basal wall. The accompanying figure (*fig. 1*) represents diagrammatically the early stages of the Riccia embryogeny as determined by Hofmeister and Kienitz-Gerloff. The first wall is approximately transverse to the axis of the archegone. Succeeding walls divide the embryo into nearly equal

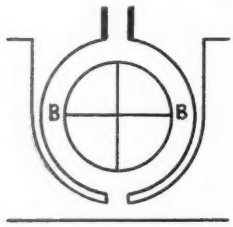


FIG. 1.— Embryo of Riccia.

[1] Vergleich. Unters. 47. 1851.

[2] Vergleich. Unters. über die Entwickelungsgesch. des Lebermoos-Sporogonium. Bot. Zeit. **32**: 166. 1874.

[3] Unters. über Lebermoos. **4**: 22. 1879.

octants. Alone among Bryophyta the embryo of Riccia (including here also the closely allied genera Ricciocarpus and Ricciella) shows very slight distal-proximal specialization, if any. The archegone stands perpendicularly upon the thallus, invaginated for protection, and the originally distal hemisphere develops in essentially the same manner as the proximal. The mature sporophyte, a globular body less than a millimeter in diameter, consists merely of a one-layered wall of sterile cells surrounding a homogeneous mass of spores, elaters being absent. The spores are released by disruption of the wall and disorganization of the surrounding tissues of the invaginated thallus and the calyptra.

Embryogeny of Sphærocarpus.— This interesting little plant was not carefully investigated until 1867, when Petounnikow made out some of the principal points in the embryogeny[4] after the early stages which apparently he did not see. In 1875 Kienitz-Gerloff[5] took in hand the investigation of this plant and practically completed it. He showed that while a considerable irregularity existed in young stages, the first wall was approximately transverse. This was succeeded by one or two other transverse walls principally in the hypobasal hemisphere, and finally periclines and anticlines in the epibasal hemisphere served to delimit the amphithecium and endothecium of the capsule. Leitgeb[6] gives a series of figures of the young embryo which together with the excellent series of Kienitz-Gerloff in the paper cited may be regarded as complete. Leitgeb suggests that its embryogeny "strongly resembles that of Fossombronia," but its resemblance seems strongest with the Marchantiaceæ, and probably the place of the plant is not with the Jungermanniaceæ as some taxonomists have thought, but with the simpler relatives of Marchantia. The mature sporophyte is a spherical capsule provided

[4] Sur les organes reproducteurs du *Sphærocarpus terrestris* Mich. Bull. Soc. Bot. de France **14**: 137. 1867.

[5] Neue Beitr. zur Entwickelungsgesch. des Lebermoos-Sporogoniums. Bot. Zeit. **33**: 795. 1875.

[6] Op. cit. **4**: 69. *pl. 9.* 1879.

with a short foot with bulbous base. Elaters are not present but nutritive cells are found among the functional spore mother cells. In *fig. 2* a diagram of the egg orientation and first segmentation is shown. The black epibasal segment is the ultimately sporogenous area, while the white hypobasal segment does not produce spore mother cells but is sterilized. The distal-proximal specialization which arises in the sporophyte is thus seen to be connected with the first segmentation plane of the egg. As will be noted in the next plant but one examined, such distal-proximal specialization need not necessarily be foreshadowed by the first segmentation plane.

FIG. 2.—Embryo of Sphærocarpus.

Embryogeny of Marchantia.— This genus was studied by Hofmeister,[7] who investigated the embryo of *Marchantia polymorpha*. In the work cited his *pl. 11, fig. 16* shows an octant stage; *fig. 30*, of the related plant *Conocephalus conicus*, shows less correctly an early stage in the embryogeny provided with an apical cell which does not then exist. As in the case of the plants previously mentioned, the important researches on the embryo of Marchantia were made by Kienitz-Gerloff[8] whose *pl. 3* in the memoir cited gives eleven figures of young embryos from the quadrant stage up to the differentiation of foot and capsule and the development of wall and archesporium. In all essential particulars this embryogeny resembles that of Sphærocarpus except that secondary transverse walls parallel to the basal wall are not formed in advance of anticlines and periclines in the capsular region. The mature sporophyte is an ovoid or spherical capsule upon a short cylindrical foot which elongates during the last stages of maturation and projects the capsule beyond

[7] Op. cit. 56. 1851.

[8] Vergleich. Unters. u. s. w. Bot. Zeit. **32**: 167. 1874.

the calyptra. In one particular, however, there is pretty generally in the Marchantiaceæ of higher rank than Sphærocarpus a modification of the primitive position of the sporophyte with reference to the horizon. Instead of being erect it is inverted more or less completely. This is due to the inversion of the archegone which, although developed dorsally on the thallus, is carried into a ventral position by displacements of growth, so that the neck of the archegone points towards the substratum. As the archegone is carried to an inverted position the egg must also be unless it rotates in the venter, a process which does not take place in ontogeny although apparently it does in phylogeny. *Fig. 3* shows in diagrammatic fashion the first segmentation stage of the Marchantia egg with the epibasal hemisphere shown black as before and now directed downward instead of upward. In either case, however, whether the embryo of Sphærocarpus or Marchantia be considered, it must be noted that the epibasal hemisphere is essentially the distal segment of the egg, while the hypobasal is as essentially the proximal. In Bryophyta a strong distinction arises between these differently situated segments and in pteridophytic types of embryogeny where the egg is frequently rotated to one side or even inverted in the archegone under ecological stress, it is always possible to distinguish the segment which is the homologue of the originally distal segment and this, whatever its position in the archegone, or with the thallus or the horizon, is termed the epibasal segment. The conception of an epibasal and hypobasal segment is therefore seen to be one of phylogeny rather than of embryogeny.

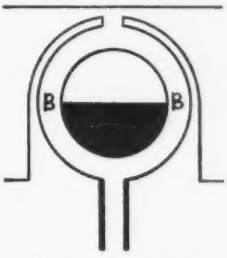


FIG. 3.— Embryo of Marchantia.

Embryogeny of Anthoceros.—While important work on the sporophyte of Anthoceros was accomplished by Schacht[9] in

[9] Beitr. zur Entwickelungsgesch. der Frucht und Spore von *Anthoceros laevis*. Bot. Zeit. **8**: 457. 1850.

1849, it was not until Hofmeister showed the independence of the rudimentary spore-producing organism from the thallus that a clear idea was possible of the early stages. Schacht's *pl. 6, fig. 2*, of the work cited, shows a young sporophyte of about twenty cells, but drawn as if a branch of the thallus. The position of the walls, however, is correctly indicated. Hofmeister,[10] in 1851, cleared up the embryogeny of this plant so far as concerned the first segmentations. His *pl. 1, fig. 36* of the work cited is practically correct, although not so much can be said for *fig. 39*. It is to Leitgeb and Waldner that we owe the modern knowledge of the Anthoceros embryogeny. Leitgeb[11] first discussed it fully in a special paper, and later Leitgeb and Waldner,[12] in their joint part of Leitgeb's classic work on the Hepaticæ, described and figured with accuracy the young plants from the first segmentation on to maturity. In Leitgeb and Waldner's memoir, *pl. 1, fig. 1* shows most clearly a young eight-celled stage, while earlier phases are described in the text. The originally formed wall is in this plant not the basal wall, but the median or transverse wall, running parallel with the axis of the archegone and dividing the egg into two halves, either anterior-posterior or right and left, since the archegone occupies a perpendicular position imbedded in the upper layers of the thallus. *Fig. 4* shows the ovoid shape of the egg, the vertical plane of the first segmentation, and the later formed plane of the basal wall which divides the egg into capsular area and foot area quite as in the Marchantiaceæ. In this egg the distal-proximal specialization is strongly marked. Not only does this appear in the position of the basal wall below the middle of the egg, but in the ovoid shape of the egg itself. The slender, columnar form

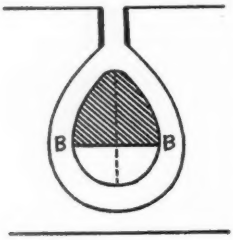


FIG. 4.— Embryo of Anthoceros.

[10] Op. cit. 5. 1851.

[11] Entwickelung der Kapsel von Anthoceros. Sitz. der K. Acad. Wiss. 73.

[12] Unters. über der Lebermoose 5: 21.

of the Anthoceros capsule capable of evolutional modification into the capsule of Sphagnum on the one hand, or the strobilus of Phylloglossum on the other, is prefigured to a degree in the egg. That the basal wall should not be the first wall formed is apparently a peculiarity not confined to this genus of plants, for in fern embryogeny the same irregularity has been noted. From the further development of the segments it is quite clear that the vertical wall first formed is by no means basal, as it is in Pilularia, and the only explanation at all satisfactory is the one given here, that it is in reality median or transverse.

Embryogeny of the Jungermanniaceæ.—In this important family of Hepaticæ there is no new type developed. Strong distal-proximal specialization is universal, and the base of the capsular tract is converted into a sterilized stalk, so that the elevation of the sporogenous area is brought about by an organ derived from the epibasal hemisphere, rather than from the hypobasal, as in Sphærocarpus. In Marchantiaceæ, as is well known, the elevation of the sporogenous area is a function not of any sporophytic organ, but principally of the archegoniophore stalk which elongates, carrying up into the air the circle of attached sporogonia. In Fossombronia, Pellia, Frullania, Lejeunia, and the other Jungermanniaceæ the embryogeny is of essentially the type described for Sphærocarpus. An additional elongation of the sporophyte is provided for in the manner described, but in general the diagram of the Sphærocarpus embryo would suffice for that of any of the others, as for any moss.

Comparison of bryophytic types of orientation and segmentation.—A glance at the figures will show that there is really but one type of egg orientation represented in this group. In Riccia there is no sharp differentiation between the epibasal and hypobasal hemispheres so far as concerns their further development. In the higher genera the hypobasal segment is invariably sterilized, while the epibasal hemisphere is wholly or in part developed into a capsular body, maturing spores with or with-

out accessory cells in the form of nutritive cells, elaters, or columella cells. In all cases the hypobasal hemisphere is proximal, while the epibasal is distal. The archegone may be erect, horizontal or inverted, but the orientation is always normal and primitive; that is to say, the epibasal hemisphere, originating as the distal half of the egg, retains constantly the distal position. This distal-proximal arrangement of the first egg segments is not disturbed in any important sense by the retardation of the basal plane in such an embryo as that of Anthoceros. Without further discussion at this point, it may be well to pass at once to the consideration of pteridophytic embryogenies, in order that their new developments may be brought before the attention.

PTERIDOPHYTIC ORIENTATION AND SEGMENTATION TYPES

Among certain genera of pteridophytes it is probable that the primitive bryophytic orientation of the egg is retained. Among others it is profoundly altered, so that the inverted embryogeny of the Lycopodinæ and of the leptosporangiate ferns presents itself for consideration. It will be shown later that the inverted embryo of the club-mosses and the semi-inverted embryos of Polypodium and Alsophila are not directly comparable, the inversion having originated under probably different stimuli in the ancestral types; that is, in a word, there is not one type of inverted orientation to be set over against the one primitive type of normal orientation. On the contrary, inversion, semi-inversion, or rotation of the egg may be shown to have arisen in different phyla under different conditions.

Embryogeny of Equisetum.—This plant was among those studied by Hofmeister,[13] who gives some correct figures of early stages in *pl. 17* of the work cited. His *fig. 16* is particularly excellent. The very early two-celled stage of the embryo is not shown, but the horizontal first division plane is duly announced.

[13] Ueber die Keimung der Equisetaceen. Abh. K. S. Gesellsch. d. Wiss. **4**: 172.

Sadebeck[14] gave a full account of the Equisetum embryogeny in 1878, and his figures serve to illuminate all the important stages. The basal wall divides the egg into a distal half as distinguished from a proximal. The distal or epibasal hemisphere develops into the shoot tract, while the proximal retains its ancestral character of a foot from which, however, the root springs endogenously (*fig. 5*). It may be regarded, I think, that the type of embryogeny shown by Equisetum is the most primitive among pteridophytes, and indicates the probable phylogenetic significance of the root as an embryonic organ of Pteridophyta. The root is developed as an emergence from the conduction-path of the nursing foot. Throughout the vegetable kingdom it almost universally arises from internal tissues, and may be regarded as a branch of the stele. The precise behavior of the hypobasal hemisphere of Equisetum, which enlarges by cell-division and growth into a bulbous body and then develops a root from an apical cell, not superficial, may be taken for a recapitulation of the original evolution of the root as an organ of the sporophyte. In this sense root is not homologous with stem, and is, indeed, a new structure. It seems to be, for the archegoniate series of plants, essentially first of all an absorptive tract, and it comes into existence through adaptation to its surroundings of the sporophyte endowed with a progressively larger photosynthetic area. This conception is in direct contradistinction to an older view, that root as a morphological area is merely the proximal end of the axis, and that its primitive function was support rather than absorption.

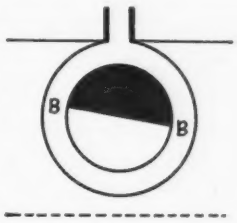


FIG. 5.— Embryo of Equisetum.

Embryogeny of Angiopteris.—Our knowledge of the early stages in the development of the Angiopteris sporophyte is due

[14] Die Entwickelung des Keimes der Schachtelhalme. Jahrb. Wiss. Bot. 11 : 575. 1878.

to Farmer[15] who has carefully investigated the first segmentations. The archegones are situated upon the lower side of the rather thick and massive prothallium. The eggs segment by a transverse basal wall followed by a median. Unlike the egg of Marchantia this egg of Angiopteris retains its original orientation with reference to the horizon, although the archegone is displaced, for protection, to the lower surface of the prothallium. The epibasal hemisphere is directed upward, hence away from the neck of the archegone, and the egg must be conceived to have rotated in the reverse direction to the archegone as it passed from the original dorsal position, as in Anthoceros, to the ventral position generally characteristic of the ferns. *Fig. 6* shows the position of the egg and its segments in the inverted archegone, and should be compared with *fig. 3*, that of Marchantia, where the inversion takes place during ontogeny and the egg is not rotated. In Angiopteris and the other Marattiaceæ which have been studied, this inversion does not take place as in Marchantia, during the life of an individual prothallium, but has evidently resulted from a slow adaptation. Opportunity has thus been given for the egg to change its position from time to time as the slight inclination of the archegone made necessary, if it was to retain its normal position with reference to the surface of the substratum. Consequently the Angiopteris stem and cotyledon bore through the prothallium, and thus come to independent illumination and the plant develops its sporangia a sufficient distance above the substratum to insure spore distribution.

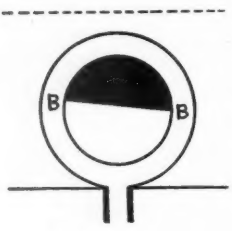


FIG. 6.—Embryo of Angiopteris.

Embryogeny of Isoetes.—The embryogeny of this plant has been studied by a number of observers of different degrees of ability, but, it seems to the writer, has never received the proper

[15] On the embryogeny of *Angiopteris evecta*. Ann. of Bot. **6**: 265. 1892.

interpretation. Hofmeister's[16] classic memoir is the first paper of importance that deals with the embryogeny. In *pl. 2, fig. 20* of the work cited he figures the first segmentation stage, and in *fig. 21* shows an octant stage. Other less correct intermediate stages are figured in *pl. 3*, but the *fig. 13*, which gives a view of an embryo with developed cotyledon, is excellent. Nearly thirty years later Kienitz-Gerloff[17] undertook an examination of this plant, and concluded a research characterized by accurate observation of the earlier stages, coupled with erroneous conception of the later. His series of figures in the work cited carry the embryo from the stage just succeeding the octant stage up to ligular development. Farmer[18] in 1890 incidentally considered the embryogeny and came to the conclusion that the first root was adventitious.

The segmentation of the Isoetes egg is briefly as follows: The egg is cleft by a wall nearly perpendicular to the axis of archegone. From the hemisphere next the archegone neck, after quadrant and octant walls have appeared, are developed the cotyledon, the root, and, later, probably from the cotyledon quadrant (not the root quadrant as has been suggested), the stem. The hemisphere away from the neck develops only a mass of cells, which has been generally considered as the foot, and so described. Now the development of a primary root from the epibasal hemisphere is so difficult an hypothesis to accept that Farmer's solution of the dilemma by considering the first root an adventitious organ would necessarily be adopted if another explanation were not at hand. It can properly be questioned, however, whether the first transverse wall formed is really the basal wall. This has been the current hypothesis, and Isoetes in its embryogeny has been compared with Equisetum, a plant which manifests, as has been indicated above, the normal bryophyte type of orientation of its egg. If, how-

[16] Zur Entwickelungsgeschichte der *Isoetes lacustris*. Abh. K. S. Gesellsch. Wiss. **4**: 131.

[17] Ueber Wachsthum und Zelltheilung und die Entwickelung des Embryos von *Isoetes lacustris*. Bot. Zeit. **39**: 761. 1881.

[18] On *Isoetes lacustris*. Ann. of Bot. **5**: 37. 1890.

ever, it be supposed that, as is certainly the case in Anthoceros, the first wall formed in the Isoetes embryo is not the basal wall, but the transverse, there is much less difficulty. It is then possible to see how the root and foot may develop from the hypobasal hemisphere, not shaded in *fig.* 7, while from the epibasal develops the strong cotyledon and a group of irregular cells which are generally regarded as constituting a portion of the foot, but should more probably be considered to be a poorly developed leaf-structure. Only half of what has been considered foot in the Isoetes embryo is here retained in that morphological category. The remainder is considered to be aborted leaf functioning as foot. The true epibasal area gives rise to the shoot while the true hypobasal area gives rise to the root. Thus the difficulty of supposing root to originate from an epibasal hemisphere is readily avoided, and by analogy with Anthoceros no violence is done to accepted ideas of embryology. In brief an Isoetes egg may be regarded as an Angiopteris egg turned through an angle of 90° in the archegone cavity, and cut by the transverse wall before the epibasal wall appears.

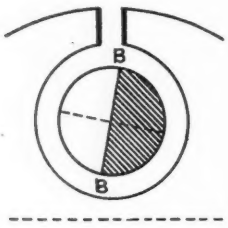


FIG. 7.—Embyro of Isoetes.

Embryogeny of Pteris.—The leptosporangiate fern embryo has been studied by a large number of observers, the first thorough work being that of Hofmeister,[20] who made out correctly the first divisions. As in the case of many of the lower plants the complete study was accomplished later by other observers. Goebel[21] contributed some important observations in a paper primarily devoted to prothallial structure, and Kienitz-Gerloff[22]

[20] Ueber Entwickelungsgeschichte und Bau der Vegetationsorgane der Farnkräuter. Abh. K. S. Gesellsch. Wiss. **5**: 615.

[21] Entwickelungsgeschichte des Prothalliums von *Gymnogramme leptophylla.* Bot. Zeit. **35**: 689. 1877.

[22] Untersuchungen über die Entwickelungsgeschichte der Laubmoos-Kapsel und die Embryo-Entwickelung einigen Polypodiaceen. Bot. Zeit. **36**: 49. 1878.

investigated the embryos of Pteris, Aspidium, Adiantum, and Gymnogramme, giving in his *pl. 3* the figures of Pteris embryogeny which have become classic. The first wall in the Pteris embryo runs almost parallel with the archegonial axis, transverse to the prothallium, and divides the egg into a smaller anterior epibasal and a larger posterior hypobasal hemisphere. The normal position of the archegone is ventral, so that at first the root and foot octants are directed obliquely upward. If, however, the archegone is abnormally produced upon the upper side or (sometimes normally) upon the margin of the prothallium the orientation is not essentially modified with reference to the archegone. This is the reverse of the condition observed in Marchantia, but, as in the liverwort, there is no revolving of the egg in its archegone venter. *Fig. 8* shows the normal position of the egg, the epibasal hemisphere being directed toward the morphological apex of the prothallium and obliquely toward the substratum.

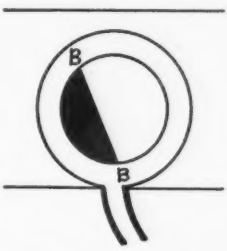


FIG. 8. Embryo of Pteris.

Embryogeny of Marsilia.—The Hydropterideæ have received their share of investigation during the last fifty years. Hofmeister[23] in 1851 examined the embryo of Pilularia, and later Hanstein[24] made a very complete study of the Marsilia embryogeny, offering in *pl. 11* of the work cited numerous satisfactory figures of the early stages. As in other leptosporangiate and, indeed, as in all heterosporous ferns, the basal wall is parallel with the axis of the archegone. Here, however, unlike Isoetes, the

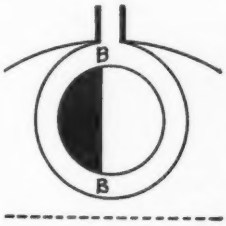


FIG. 9.—Embryo of Marsilia.

[23] Vergleich. Unters. 106. 1851.

[24] Die Befruchtung und Entwickelung der Gattung Marsilia. Jahrb. wiss. Bot. 4: 197. 1866.

first wall to form is the basal wall, separating, as in Pteris, a smaller laterally-placed epibasal hemisphere from a larger hypobasal. In *fig. 9* the orientation is indicated as described, and the further development of the hemispheres, as in the case of Pteris, is too well known to need any extended description.

Embryogeny of Lycopodium.— For many years the sole investigated lycopodineous embryo was that of Selaginella so ably studied by Pfeffer,[25] but in 1884 Treub[26] presented the first figure of an embryonic Lycopodium plant, something which had been diligently looked for during many previous years. In this first paper the account was incomplete, but two years later Treub[27] was able to announce most of the stages in the embryogeny of *Lycopodium phlegmaria*. Confirmation of Treub's researches was given within a year by Goebel,[28] who, however, does not figure any young stages of the embryos studied by him, his sketch of the young plant of *Lycopodium inundatum* being about as far along in development as was Treub's *Lycopodium cernuum* embryo of his 1884 contribution. From the brilliant investigations of Treub and Pfeffer in particular the embryogeny of the Lycopodinæ may now be said to be thoroughly known, although as for so many other groups the foundation here was really laid by Hofmeister,[29] who figured as long ago as 1851 a two-celled embryo of *Selaginella denticulata*, and showed the peculiar suspensor in its proper relation to the rest of the embryo. In Lycopodium, more instructive than Selaginella because its prothallium is less vestigial, the archegones may be regarded as dorsal, and the egg within the archegone segments perpendicularly to the archegone axis, as in Equisetum. It is, however, the hemisphere towards the base of the archegone

[25] Die Entwickelungs. des Keimes der Gattung Selaginella. Hanst. Bot. Abh. 1 : 32. 1871.

[26] Études sur les Lycopodiacees. Ann. Jard. Buitenzorg 4 : 129. 1884.

[27] Études sur les Lycopodiacees. Ann. Jard. Buitenzorg 5 : 115. 1886.

[28] Ueber Prothallium und Keimpflanzen von *Lycopodium inundatum*. Bot. Zeit. 45 : 169. 1887.

[29] Vergleich. Unters.

which has the power of principal development, and it is therefore this hemisphere which must be regarded as epibasal. The hemisphere toward the archegone neck forms the well-known suspensor-cell, and is clearly the homologue of the foot in mosses, liverworts, equisetums, and ferns. The first root in Lycopodium and Selaginella together with a nursing organ, misnamed the "foot," arise adventitiously from the epibasal hemisphere. As compared, then, with Equisetum the egg of Lycopodium must be regarded as having undergone rotation through an angle of 180°, bringing the primitive hemispheres into a position just the reverse of their original one.

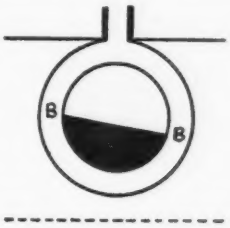


FIG. 10.—Embryo of Lycopodium.

Comparison of pteridophytic types of orientation and segmentation.—It seems to assist toward a clear conception of pteridophytic embryogeny to regard Equisetum as manifesting the primitive orientation and segmentation, and to interpret the other types as derivations, primary or secondary, from this fundamental bryophyte-like method. The Pteris and Lycopodium embryogenies may be considered as modifications due to adaptation. There are then at least these principal types:

A. Primitive orientation, *e.g.*, Equisetum.

B. Semi-inverted orientation, *e.g.*, Pteris.

C. Inverted orientation, *e.g.*, Lycopodium.

It will be noted that the type of Angiopteris must be connected with that of Equisetum. The hemispheres of the Angiopteris embryo lie in the original plane with reference to the substratum, the epibasal distally and the hypobasal proximally. Owing to the modified position of the archegone, on the ventral rather than on the dorsal side of the thallus, the epibasal hemisphere while retaining its primitive position with reference to the substratum comes into an entirely reversed position with reference to the archegone. The epibasal hemisphere now

faces the base of the archegone instead of the neck. If it be accepted that the new position of the Angiopteris archegone as compared with the position of the same organ in the archetypal Anthoceros is an adaptation for protection it is apparent that class A above is easily divided into two subclasses as follows:

A. Primitive orientation.

1. Archegone in original position, *e. g.*, Equisetum.
2. Archegone in adaptive position, *e. g.*, Angiopteris.

To interpret the semi-inverted orientation of Pteris from the conditions in Angiopteris is possible if we regard it as a further adaptive modification. It may be conceived to be of advantage to the young embryo to grow through the least resistant tissues of the prothallium upon the ventral side of which it had originated. Any tipping of the egg so that the epibasal hemisphere should incline towards the growing point of the prothallium would subserve this end, and at the same time would more definitely place the absorptive hypobasal area in the most advantageous position with reference to the older, nutriment-containing portion of the gametophyte. Such an adaptive tipping forward of the epibasal hemisphere would be perpetuated, and at the same time might be accentuated until the change in position exceeded 90° as is the case if one compares Pteris with Angiopteris. The position, then, of the epibasal hemisphere of the Pteris embryo has an interesting suggestion concerning the phylogenetic history of the prothallium. Clearly the delicate almost unilamellar prothallium of the Polypodiaceæ offers slight resistance even if an embryo were to penetrate it directly with its cotyledon or stem-apex. Therefore it seems reasonable to regard the semi-inverted embryo as suggesting that the ancestral prothallia were much thicker, and that the habit of tipping forward dates from the time of thick prothallia. This is precisely in accord with many other bits of evidence all of which bear toward the same conclusion. And, *pari passu*, the position of the embryo in Trichomanes, suggesting as it does the reduced character of the filamentous prothallium, renders it difficult to con-

nect the Hymenophyllaceæ directly with the bryophytes, as was the custom of the older pteridologists.

There is naturally no difficulty presented by the embryogeny of Marsilia, nor by that of the closely related Pilularia or of the not distant Salviniaceæ. In all of the Hydropterideæ the semi-inverted leptosporangiate fern embryogeny persists, except that the angle of variation from the original position is here quite exactly 90°. This perpendicular position of the basal wall may be in some way an adaptation to heterosporous conditions, and may be connected with the positions of the nursing foot and of the emergent cotyledon and stem-apex. At any rate, it characterizes Isoetes, as explained above, and may be said to be the mark of all heterosporous pteridophytes of which the embryo is not provided with a suspensor. Two subclasses, therefore, may be defined under class B above :

B. Semi-inverted orientation.

1. Sequence of segmentation planes normal, *e. g.*, Pteris.
2. Sequence of segmentation planes abnormal, *e. g.*, Isoetes.

In the case of a plant so strongly isolated as is Isoetes speculation is scarcely profitable in an attempt to explain the origin of the perpendicular basal wall. It may have been derived from either an Equisetum-like or Angiopteris-like, or even Pteris-like ancestral form. Certainly it is of all pteridophytic types the most disconnected, as it is in some respects the most peculiar. Whether the original tip-to-one-side began to characterize its embryo because a resistant prothallial mass lay between the embryo and the outer world, or because homosporous conditions were gradually changed to heterosporous, and the nutriment supply and the megaspore wall exerted an influence upon the position of the young hemispheres, in any case the position must be regarded as one of adaptation. Just how the adaptive position arose in this plant will possibly never be certainly suggested.

The inverted egg of the Lycopodinæ is very easily explained, so far as the nature of the adaptation is concerned. Plainly

enough the use of the suspensor or foot-homologue is to push the epibasal hemisphere into the center of the prothallium where the food-supply will most abundantly and symmetrically surround the developing segment. But to explain in any reasonable way how this remarkable inversion of the egg originated is quite another matter. The archegone in Lycopodium may be regarded as occupying a dorsal position on the thallus as in the case of Anthoceros. The Lycopodium prothallium, as seen in a primitive type like that of *Lycopodium cernuum*, not modified by adaptation to saprophytic nutrition, is comparable with an Anthoceros thallus, not only in the origin of the sexual organs but in the vegetative tract also. Yet it is inconceivable, I think, how an egg developing after the manner of an Anthoceros egg should invert itself in the archegone, convert its foot into a suspensor, and develop from its abnormally oriented epibasal cell the stem-axis and an adventitious nursing and absorptive tract. The inverted position of the Lycopodium egg cannot then be regarded as a primitive modification of the Anthoceros conditions. Rather would it appear that between the Anthoceros embryogeny and the Lycopodium embryogeny some other type had intervened.

It is possible, though no doubt extremely speculative, to refer the inversion of the Lycopodium egg to a double displacement, under adaptive conditions, of the archegone in the ancestral forms. While the archegone was situated on the ventral side of the prothallium the tipping of the embryo took place as in the ancestors of the Polypodiaceæ; following this the archegone worked back to the upper surface of the prothallium carrying the egg in its derived position. As the archegone returned, in successive generations, more and more to the ancient dorsal position, the embryo adapted itself to the most favorable position for nutrition and subsequent development, and when heterospory originated, the Selaginella type, in which the embryonic epibasal tract is immediately thrust into the center of the spore by the elongation of the primitive foot area, came into existence. Such an epibasal area of the embryo so placed

must have early begun the development of an adventitious "foot" and root.

PHANEROGAMIC ORIENTATION AND SEGMENTATION TYPES.

All segmentation types among flowering plants, with the possible exception of that manifested by the extraordinary plant *Ginkgo biloba*, are referable to class C. Various secondary ecologic modifications have arisen, the most remarkable being the meroblastic segmentation in Coniferæ, the free-nuclear segmentation in the Gnetales — a phenomenon ecologically comparable to the free-nuclear origin of female prothallial tissues in Selaginella or to endosperm origin in most seed-plants — and the reduction of the suspensor, as in Pistia, Listera, Cypripedium, the Mimoseæ and Hedysareæ among others. It is not possible, however, to name any suspensorless flowering plant embryo except that of *Ginkgo biloba*, in which the absence of suspensor is not plainly and unmistakably a secondary adaptation. In Ginkgo alone is there a suggestion that the embryogeny belongs to the general fern type rather than to the lycopodineous. Other well-known old and new facts about Ginkgo should be considered in this connection but will here be passed over without further notice.

GENERAL CONSIDERATIONS.

Adaptive phenomena in reproductive tracts.—Unquestionably, like all other organs of the plant, those concerned with reproduction are more or less exactly adapted to their environment. It is true they are less plastic than the organs of the vegetative tract, and hence do not show the epharmonic characters so variously as stem, root, and leaf structures may. For this reason they are quite universally, by modern as by ancient taxonomists, employed as the landmarks of phylogeny, not easily shifted by transitory outward influence. Yet form and structure not primarily connected with their special functions may be imprinted upon then and developed in them. Special positions are assigned them under outward stimulus, and their structure, shape, size,

attitude, and behavior may all come to have some definite relation to the *melange* of forces and substances that surround them. Compare, by way of illustration, the almost globular form of the spermary in Anthoceros or Dendroceros, growing under a pressure exerted by the cellular roof of the schizogenetic cavity in which the organ develops, with the elongated cylindrical spermary of Polytrichum situated upon its short pedicel in the axil of a bract of its "inflorescence." The shape of the one differs from that of the other not on account of different reproductive specialization but purely because molded by lateral pressures while the other is subjected to vertical. Again a similar reaction to outward conditions is to be observed in the convexity anteriorly of the so-called "neck" of the Polypodium archegone. Evidently enough this curved cylinder, differing morphologically as well as ecologically from the straight true neck of a moss archegone, is a response in form to its acquired ventral position upon the prothallium and to the forward growth of the prostrate sexual plant. The convexity may be regarded as a purely adaptational phenomenon determined by a group of conditions among which are the growth habits of the prothallium, the ventral position of the archegone, the extension of the "neck," and the resistance and friction of the substratum.

The primitive position of the sexual organs seems more intimately reproductive in its significance, than adaptational. That is, the position upon the plant-body of the rudimentary egg-maturing or sperm-maturing cell is determined by the conditions of accurate reproductive functioning, and not until considerable organs are evolved do the purely adaptive changes become important. The well-known and closely related plants Œdogonium and Bulbochæte, from their simplicity are suggestive. In Œdogonium, which consists of unbranched filaments, the egg, cells are intercalated between vegetative cells. In Bulbochæte, however, where branching is common, distal-proximal specialization makes itself felt, and the oogonia and antheridia are disposed terminally upon the branches, bringing them to the general sur-

face of the thallus where interference of closely packed branches will not hinder the egg-seeking, locomotive movements of the sperms. Together with this definite peripheral location of the sexual cells arises the need for protection of them from injurious impacts of all sorts and sharp bristling chætæ are developed.

In many Hepaticæ by invagination, and in Musci by envelopment with bracts, the sexual organs are protected, and the exposure due to their morphologically peripheral position is modified or almost completely negatived. In Anthoceros the protective instinct results in the habit of developing the spermaries in actually closed cavities, not to be opened until the sperms are quite mature. Such derived positions while adaptational in the truest sense must be admitted to have important effects upon the reproductive rank of the organs or organisms in question.

Primitive reactions of segmenting eggs to their environment.—The first necessity that confronts a plant egg is that its position be such as to insure fecundation. That this may take place it is necessary that the egg should be protected against harmful influences, but should be exposed to the ingress of the sperm. After fecundation it is necessary that the embryo should be protected and nourished and that it should, with the least waste of matter or of energy, develop into a functional sporophyte. The function of a sporophyte may be briefly defined as the manufacture of as *many* and as *certainly germinable* spores as possible. Under such necessities the eggs are at first peripherally disposed with such protective layers about them as may have been developed and maintain this general position until spermatozoid-fecundation is abandoned, passing over through the Ginkgoales and Cycadales to pollen-tube fecundation.

The primitive segmentation-types as seen in Riccia may have originated under direct stimulus by the force of gravity, as has been suggested, but very early the direction of the basal wall became fixed with reference to the archegone axis and thereafter could be changed only in course of extended evolution. The distal-proximal specialization of the archetypal embryos, bringing into existence an epibasal as distinguished from a hypobasal

hemisphere, was an immediate consequence of the two conditions already mentioned, viz., transverse segmentation and peripheral position of the archegones. The persistence of the function of sporogeny in the epibasal hemisphere cell-descendants, and the disappearance of this function from the hypobasal tract is a most natural division of labor, and in each area improvements for reproduction and for absorption have been steadily evolved. By the relations of the young embryo to the parent prothallium and by the ancestral relations, orientation is determined. This is an adaptive phenomenon.

Kienitz-Gerloff[30] in a general article suggests, without having considered, however, a very full series of forms, that torsions (Drehung) may explain the oblique position of the Pteris epibasal segment as compared with that of the mosses, seeming to propose a spontaneous shifting of the plane of segmentation. This explanation I am unable to accept for the whole group of positions seems to be clearly adaptive. In the paper cited, Kienitz-Gerloff gives four diagrammatic longitudinal optical sections of embryos illustrating his idea of lateral torsion. This paper is of interest also from its ingenious though faulty determinations of homologies between Bryophyta and Spermatophyta, in quite the manner of the older school of embryologists.

SUMMARY.

1. The orientation of the plant-egg is at bottom a phenomenon of adaptation.

2. The conception of a basal wall is founded upon facts of phylogeny so profound that it is necessary to recognize that wall as basal which separates morphologically distal from morphologically proximal regions. The first wall formed may or may not be the basal wall.

3. Three principal types of egg-orientation are recognized: the *primitive* or bryophytic, characteristic also of Equisetum and Angiopteris; the *semi-inverted*, characteristic of Isoetes and the

[30] Ueber den genetischen Zusammenhang der Moose mit den Gefässkryptogamen und Phanerogamen. Bot. Zeit. 34: 705. 1876.

leptosporangiate ferns; and the *inverted*, characteristic of Lycopodinæ and Spermatophyta.

4. The origin of the primitive type is in adaptation to the peripheral position of the archegones and to the plane of the substratum; the origin of the semi-inverted type is in adaptation to derived archegonial positions and resistance of prothallial areas, interfering with the direct normal growth of the embryo; the origin of the inverted type is in adaptation to repeated archegonial displacements and nutritive qualities of prothallial areas adjacent.

5. The phylogenetic sequences derived from such an ecological investigation of embryos do not materially differ from those derived by a study of pure morphology.

UNIVERSITY OF MINNESOTA.

A CONTRIBUTION TO THE LIFE HISTORY OF THE PONTEDERIACEÆ.[1]

WILSON R. SMITH.

(WITH PLATES XIX–XX)

THE following investigation of *Pontederia cordata* was begun in the winter of 1897 as supplemental to a course in the special morphology of monocotyledons, under the direction of Dr. John M. Coulter. In the following summer, for purposes of comparison, I collected and studied material of *Eichhornia crassipes*. This is, so far as I know, the first examination of the gametophyte generation of any of the Pontederiaceæ. While the results, as might be expected, do not show any wide deviation from the usual series of events in monocotyledons, they have a value as indicating the extent of variation within a given order, and, in the case of Eichhornia, within a given species.

I wish here to acknowledge my indebtedness to Dr. Coulter for criticisms and valuable suggestions:

EICHHORNIA CRASSIPES.

MICROSPORES.

Fig. 30 represents a cross section of one of the youngest anthers I obtained. The tapetum is a distinct layer of small cells closely adherent to the spore mother cells, and often wedged in among them. Outside the tapetum are usually five layers of wall cells, the innermost of which appears always to disintegrate before the tapetum gives any clear signs of collapse. It is well known that in their later stages the tapetal cells of anthers are likely to become binucleate. Such a condition I have never found in a single case either in Eichhornia or in Pontederia. In the ripe anther there are, as usual, two layers in the wall, the

[1] Contributions from the Hull Botanical Laboratory. IX.

inner of which has the characteristic reticulate thickenings of an endothecium.

The mother cells are very large in comparison with the surrounding cells. About the time they break apart and become rounded, there is a very considerable increase in size. The chromatin assumes a beaded structure and the nucleus enters into the synapsis stage, which has been frequently described in mother cells. The chromosomes, when first distinguishable, are thick and irregular, and lie scattered about in the nuclear space. When arranged in the equatorial plate they have become more regular in outline and can be counted readily. The number is sixteen (*fig. 32*), and the same number appears in the second division (*fig. 35*). This is the reduction number. Although I have not been able to count with certainty the chromosomes in the ordinary vegetative nuclei, I have ascertained the number to be not far from thirty.

Successive stages in the two divisions which end in the formation of the microspores are shown in *figs. 31–36a*. The divisions, as common in monocotyledons, are successive, each daughter cell forming a wall about itself before the second division. So far as observed, the nuclei resulting from the first division do not enter into a resting condition. Very frequently they have no nucleoli, and in such cases there are numerous bodies in the cytoplasm which stain like nucleoli (*fig. 34*). These bodies may also be seen in the cytoplasm even when a distinct nucleolus is present within the nuclear membrane.

The usual arrangement of the tetrads is shown in *fig. 36* (*cf. 35* and *35a*), but such a grouping as *36a* is quite common.

As the microspores continue to enlarge they assume an ellipsoidal shape. The generative and tube nuclei, very unequal in size, first appear when the flowers are about one-third grown; but their origin from the primitive microspore nucleus I did not succeed in observing. The cytoplasm about the small generative nucleus is organized into a clearly outlined spindle-shaped cell, which becomes longer and longer as the microspore matures, until its ends thin out into whip-like filaments (*fig. 40*). Its

cytoplasm at the same time becomes highly granular (*figs. 40, 41*).

Another peculiarity of the microspores is the frequent occurrence of a division of the tube nucleus (*figs. 41, 41a*). It is impossible to regard either of the large nuclei of *fig. 41* as a sister of the generative nucleus. The latter is set apart within a separate cell quite early in the history of the microspore, and keeps a constant outline and appearance whether or not the third nucleus is present. Furthermore, the two free nuclei are too large to be so explained, and are alike in every particular, having all the characters by which the tube nucleus is usually distinguishable. Each has a prominent nucleolus, and shows an erythrophilous reaction in staining with haematoxylin and erythrosin, while the generative nucleus has no nucleolus, very abundant chromatin, and cyanophilous staining.

So far as I know, a division of the tube nucleus has been recorded only by Dr. Chamberlain[2] of this laboratory in the case of *Lilium Philadelphicum*, where its occurrence is rare. In Eichhornia, however, fully half of the mature pollen grains examined exhibit this peculiarity. The fate of these tube nuclei, and whether or not there is a division of the generative cell in the pollen tube, I did not succeed in determining. In longitudinal sections through the style pollen tubes were easily seen traversing three central canals, but almost always they showed marks of disintegration. Since Eichhornia does not set seed in our latitude, and there are apparently no abnormal structures in the embryo sac, it is probable that the division of the tube nucleus is due to pathological conditions in the pollen grains, and the failure to produce seed should be ascribed to the same cause.

MEGASPORES.

The youngest flowers obtained had the carpels already fused in such a way as to contain three loculi, and in each of these two longitudinal ridges run along the central axis. These ridges are the six placentæ. The only sign of the ovules at this time

[2] Life history of Lilium Philadelphicum. BOT. GAZ. **23**: 423–430. 1897.

perceptible is the undulated outline of the placenta as seen in longitudinal section (*fig. 1*). In older flowers the placentæ have become distinctly papillate. The dome-shaped prominences shown in *fig. 4* are the young ovules. They are not arranged in regular rows, but are scattered so that every cross section runs through two, three, or four to each placenta.

At this time, or a little later, the archesporial cell is first apparent. Its nucleus is larger and less deeply stained than those of the surrounding tissue, while its cytoplasm is more dense and stains more deeply, especially with erythrosin (*fig. 5*). As the ovule enlarges the archesporial cell divides unequally by a periclinal wall into an outer primary tapetal cell, and a larger primary sporogenous cell (*fig. 6*). The primary tapetal cell may remain undivided, but usually it divides into two by an anticlinal wall. The plane of division is either parallel to the axis of the flower, as in *fig. 7*, or at right angles to this axis, as in *fig. 9*. The tapetal cells at once begin to lose their characteristic staining, and before their final disappearance are distinguishable from the other cells of the hypodermal layer only by their position. If, however, the primary tapetal cell does not divide, it retains its staining reaction more or less persistently to the last. The axial row of which the archesporium is the terminus also divides into two rows (*fig. 7*).

The further course of development of the primary sporogenous cell may be along two entirely different lines, which lead however to the same result, viz., the formation of a row of four megaspore mother cells, of which only the lowest one is fertile. These two series may be compared with those figured in Strasburger's *Angiospermen und Gymnospermen* for *Tritonia aurea* and *Anthericum ramosum* respectively. In the one case the primary sporogenous cell gives rise at once by successive divisions to a row of four cells, of which the lowest is always much the largest (*figs. 8* and *9*). In the other case, most common in Eichhornia, the elongation of the ovule is accompanied by an elongation of the primary sporogenous cell without division of the latter (*figs. 11* and *12*). The nucleus also enlarges and invariably remains at

the apex. Some idea of the relative length of time during which this state of things continues may be gained by comparing the integuments of *figs.* 7 and 8 with 10 and 11.

The subsequent divisions in the elongated sporogenous cell take place in quick succession. I have obtained a very large number of karyokinetic figures of these divisions, for since Eichhornia is peculiar in having all the flowers of a spike in pretty nearly the same stage of advancement, a single spike may yield upwards of two thousand ovules all of nearly the same age. The first spindle is in the apex of the cell and the division is very unequal (*fig.* 12). There is no uniformity in the order in which the succeeding divisions occur. Sometimes the upper cell divides first, sometimes the lower; more rarely, as in *fig.* 13, they divide simultaneously. The spindle in the upper cell is almost always obliquely placed (it may even be transverse), and it is doubtful if cell division is ever completed or even a cell plate formed. The division in the lower cell is also unequal, so that the lowest cell of the four, the fertile mother cell, is from the very first quite as large as the three sterile ones together (*fig.* 13). From a study of a large number of cases, similar to *figs.* 14 and 15, I have been led to believe that the four mother cells when formed in this way are seldom, if ever, separated by walls.

All shades of transition between the two lines of megaspore development described above may easily be found even in the the same flower. Thus *figs.* 11, 12, 13, 16, 17 and 18 are all from the same ovary. *Fig.* 17 shows a case in which the first division of the primary sporogenous cell has taken place when it is about half grown. In *fig.* 16 it will be seen that after the first division only the lower cell has lengthened and divided, and, though a division of the upper cell has begun, this has been stopped by the encroachment of the two cells below.

The three sterile mother cells, and after them the tapetal cells and other cells in the apex of the nucellus, are rapidly absorbed by the growing megaspore, which soon comes to abut directly against the epidermis. In the absorption of

these cells there is no appearance of crowding; their walls break down and their protoplasm becomes continuous with that of the megaspore (*fig. 24*). Before the complete absorption of the tapetal cells the nucleus of the megaspore, situated about the middle of the cell, divides into two (*fig. 24*). The lower half of the megaspore at this time ceases to grow, while the upper half widens out and assumes the shape shown in *figs. 25–27*.

The division into micropylar and antipodal groups of four nuclei follows in the usual way without any regular time order. *Fig. 25* shows an embryo sac with four nuclei, *fig. 26* with eight nuclei, *fig. 27* fusion of the polar nuclei. The position of the definitive nucleus is always near the place where the embryo sac contracts into the narrow basal portion. This nucleus is large, has a very large, clear nucleolus, and is connected with the wall of the sac by strands of protoplasm. The fusion of the polar nuclei certainly occurs before pollination, for I have found the fusion accomplished in a flower whose perianth was not yet unclosed. That this act is not dependent upon the entrance of the pollen tube is proved very conclusively in *Caltha palustris*, where I have observed sterile ovules through whose thickened walls no pollen tube can pierce, yet whose embryo sacs always reach the seven-nuclear stage. In Eichhornia, also, the embryo sac always reaches the mature condition, in which, as we have seen, most of the pollen tubes break down without penetrating to the micropyle.

The antipodals of Eichhornia are evanescent, staining feebly from the first, and rarely with definite walls. Their nuclei do not divide either directly or by mitosis.

The egg apparatus has the usual arrangement. The synergids are provided with striated "filiform" tips and a prominent vacuole. The egg is relatively small and appears to be slung to the bases of the synergids (*figs. 28, 29*).

I have found a pollen tube reaching to the embryo sac in but one case, and that is represented in *fig. 29*. The single nucleus in the tip of the tube is probably one of the male nuclei,

or possibly it is the generative nucleus itself, with which it agrees in size and staining. Its deep blue color is in strong contrast to the red of the synergids and oosphere, and of the tube nuclei of the microspores.

Since no embryos are formed the contents of the embryo sac sooner or later disorganize, always in this order: antipodals, synergids, oosphere, definitive nucleus. The definitive nucleus persists long after the other constituents of the embryo sac have disappeared. In a few instances a small number of free endosperm nuclei were found, and in one case these had arranged themselves into an incomplete parietal layer, but no cell formation of the endosperm was observed. Whether fertilization had been effected in these cases I could not make out, but the egg which was still intact had made no progress toward the development of an embryo. The coincidence of the usual failure of the pollen tube to penetrate to the oosphere with the infrequency of a division of the definitive nucleus lends weight to the generally accepted view that the stimulus which induces this division is the act of fertilization.

INTEGUMENTS OF THE OVULE.

The beginnings of the integuments may be seen in *figs. 6–8*. About the same time there begins a bending of the ovule which checks the growth of the outer integument where it comes in contact with the funiculus. By the time such a condition is reached as that shown in *fig. 12* the ovule is completely anatropous. The integuments are each two cell layers in thickness, with the cells above the micropyle much the largest. The absent portion of the outer integument next to the funiculus is represented by a thin layer of empty cells.

CYTOLOGY.

Only a few additional remarks need be made. I have not found Eichhornia a favorable subject for the study of cytological phenomena. Oil cells and glandular cavities are abundant, and a mucilaginous secretion pervades the cells and interferes

with the transparency of the stains. Delafield's haematoxylin and erythrosin, and, in ovaries isolated from the perianth, anilin-safranin and gentian-violet gave the best results. Numerous other combinations were tried, but all were more or less unsatisfactory.

A typical spindle of the first karyokinesis of the elongated megaspore mother cell is represented in *fig. 20*. The large fibers attached to the chromosomes are plainly seen to be composed of many delicate threads. On the other hand the fibrillar structure of the central spindle is less clearly perceptible.

Cytoplasmic radiations about the poles occur in all good preparations and frequently the individual rays appear to terminate externally in large granules which stain like nucleoli. The chromosomes, 14 to 16 in number, were never seen to assume a V-shaped outline at any stage of the nuclear division. This statement holds good also for Pontederia, where by the use of iron-alum-haematoxylin a sharper definition of the chromosomes was secured.

All the preceding description of the spindle will apply equally to the divisions of the pollen mother cell.

The nucleus of the elongated sporogenous cell passes through a synapsis phase. If such a phase precedes the first division when that occurs early (as in *fig. 12*) I found no evidence of it. Perhaps no special significance can be assigned to the case shown in *fig. 18* (see also *figs. 22* and *23*), in which the two sporogenous cells whose nuclei are in synapsis have arisen apparently from the early division of the primary sporogenous cell. But if, as has been suggested by some cytologists, synapsis occurs only in those cells in which a reduction of the number of chromosomes is going on, it would follow that when the primary sporogenous cell divides early without elongating, the chromosome reduction takes place in each of the resulting nuclei; whereas if the primary sporogenous cell elongates before dividing, the reduction is completed in the first nucleus.

PONTEDERIA CORDATA.

Longitudinal sections of very young spikes furnished a complete series for the study of the organogeny of the flower. The order of succession of the floral organs is acropetal (*fig. 42*) and need not be dwelt upon. Both in stamens and carpels traces of zygomorphy are very early recognizable.

The first indication of the ovule is a slight swelling on the inner wall of the lowermost carpel which is always the smallest (*figs. 43, 43a*). Normally but one ovule makes its appearance. I had expected to find the beginnings of ovules in each of the three loculi, but the facts are otherwise; out of the hundreds of ovaries sectioned I found but seven cases of a second ovule beginning, and no case of a second ovule reaching maturity.

The various stages from the differentiation of an archesporial cell to the completion of the embryo sac can be followed easily in the plate (*figs. 44–53*). A few comments only will be necessary here. The dividing wall of the primary tapetal cell runs always, so far as I observed, in the same plane with reference to the axis of the flower. There is reason to believe that quite often but three megaspore mother cells are formed. The lengthening of the ovule is effected in part by an elongation of the epidermal and tapetal cells and the other cells of the nucellar apex (*figs. 45–47, 48–52*). Later, however, those cells of the nucellus which have escaped destruction by the growth of the megaspore divide transversely (*cf. figs. 48* and *53*). The bending of the ovule is at first in a plane passing through the axis of the flower. Afterwards the funiculus twists through an arc of ninety degrees so that the ovule comes to lie as shown in *fig. 45*.

The embryo sac is very poor in protoplasm. A large central vacuole is formed and the cytoplasm is pushed to the wall as a very thin layer (*figs. 50–52*). The egg apparatus is remarkably small and is crowded against the micropylar end. The definitive nucleus lies low down in the sac, and is suspended by the strings of protoplasm trailed together by the polar nuclei (*cf.*

figs. 52 and *53*). The antipodals here also are ephemeral, becoming very indistinct at the time of fertilization and soon after vanishing altogether.

The development of the microsporangia and microspores presents no unusual phenomena. As in Eichhornia the layer of cells outside the tapetum disintegrates before the latter and the tapetal cells are always uninucleate. *Figs. 57–65* represent stages in the division of the mother cells and growth of the microspores. Neither the generative nor the tube nucleus exhibits any of the abnormalities observed in Eichhornia.

The pollen tubes in their growth through the style are conducted along three canals which are each lined with a single layer of glandular cells (*fig. 55*). This layer is continued to the micropyle (*fig. 56*). The pollen tube entering the embryo sac was seen in several cases always passing between the synergids, one of which it destroys. Vestiges of the remaining synergid are still in view when the embryo has grown to such a size as in *figs. 67* and *68*. Apparently the pollen tube brings in two nuclei and its swollen end reaches almost, or quite, to the oosphere nucleus before these are set free (*fig. 54*).

A few stages of the young embryo are shown in *figs. 66–71*. The statement made in text-books that the roots of Pontederia have no dermatogen and hence no true epidermis applies only to the secondary roots. In the young embryo (see *figs. 70, 71*) a dermatogen is regularly cut off, and this in older embryos is continuous with the calyptrogen.

No attempt was made to study the cytology of Pontederia further than to determine the number of chromosomes, which is eight in the pollen mother cell, and fifteen or sixteen in the nuclei of the sporophyte tissue.

HETERANTHERA GRAMINIS.

A few ripe flowers of this species were sectioned and examined. In general appearance the ovule, with its integuments and embryo sac, bears a striking resemblance to those of Pontederia and Eichhornia. The synergids are longer and more

prominent, however, and the embryo sac while smaller is more densely filled with protoplasm (*fig. 72*).

CONCLUSIONS.

I had hoped by a comparative study of closely related monocotyledons, and also of related dicotyledons, to be able in some degree at least to show how far the characters of the gametophyte generation could serve the purpose of indicating relationships among the larger groups of angiosperms. In this hope I have been disappointed. Those characters of the gametophyte generation in which, for example, Pontederia and Eichhornia agree, are characters which are common to hundreds of species of widely separated orders. The origin of the sporogenous tissue from the hypodermal cell terminating an axial row, the well-nigh universal occurrence of four megaspore mother cells of which but one matures, the usual cutting-off of a tapetal region which is finally absorbed by the growing megaspore, the division of the megaspore nucleus into eight free nuclei which are arranged in two groups of four each, the fusion of the polar nuclei to form a definitive nucleus which is the mother nucleus of the endosperm—these are the gametophytic characters of angiosperms in general. As soon as the comparison is pushed further we see that the differences between the two species in respect of the gametophyte are quite as great as often in other cases between unrelated plants, and the most striking resemblances, such as the shape of the ovule, embryo sac, and integuments are really sporophyte characters. If we were to draw up a tabular statement of the points in question in which Eichhornia and Pontederia agree, it would consist of two items: the ephemeral nature of the antipodals, which, however, is a characteristic of most monocotyledons; and the structure of the endosperm. Probably the female gametophyte of angiosperms has been so long parasitic upon the sporophyte that its only constant features are those of overwhelming phylogenetic importance, and its minor characters are readily variable in adaptation to the specific or generic differences of the sporophyte, or perhaps even to

changes of environment. It seems, therefore, that the gametophyte characters cannot be of much value in assisting us to trace phylogenetic relationships among the angiosperms.

The irregularities which have been pointed out in Eichhornia may be correlated with its enormous power of vegetative reproduction. It has been propagated for years, without apparent loss of vitality, in the greenhouses and parks of Chicago, solely by this method; and no doubt this is its chief means of increase in the rivers of Florida and South America, where it has become a serious hindrance to navigation. The variations in the megaspore series are interesting, since they suggest how the megaspore of Lilium may have arisen from a type which had normally a tapetum and four megaspore mother cells. Let the change in Eichhornia go but a step further, let the nuclei which fail to form cells about themselves cease altogether to appear, and we should have a primary sporogenous cell passing without division into an embryo sac. Loss of the tapetum, as apparently occurs in *Hemerocallis fulva* by the same process (see the figures in *Angiospermen und Gymnospermen*), would result in the well-known habit of Lilium, where the archesporial cell develops directly into the embryo sac.

THE UNIVERSITY OF CHICAGO.

EXPLANATION OF PLATES XIX AND XX.

The plates have been reduced to ten twenty-sevenths of their original size. The magnifications given are those of the original drawings.

PLATE XIX.

Eichhornia crassipes.

FIG. 1. Longitudinal section of young ovary showing placenta. × 80.

FIG. 2. Cross section of an ovary of the same age as *fig. 1*. × 125.

FIG. 3. One of the placentæ of *fig. 2*. × 1300.

FIG. 4. Cross section of an older ovary. The cross indicates the position of the ovule which is shown in *fig. 5*. × 125.

FIG. 5. Longitudinal section of young ovule with archesporial cell. × 1300.

FIG. 6. An older ovule showing the primary tapetal cell (*t*) and primary sporogenous cell. × 1300.

FIG. 7. Ovule with primary sporogenous cell and two tapetal cells. × 1300.

FIG. 8. Ovule with two tapetal cells and two cells derived from division of the primary sporogenous cell. × 1300.

FIG. 9. Apex of nucellus with four mother cells. × 1300.

FIG. 10. Ovule showing primary sporogenous cell elongating. × 1300.

FIG. 11. Ovule with elongated primary sporogenous cell still undivided. × 825.

FIG 12. First division of the primary sporogenous cell. × 825.

FIG. 13. Second division in the megaspore series. × 1300.

FIGS. 14 and 15. Apex of nucellus with four megaspore mother cells. × 825.

FIGS. 16–19. Irregular development of the megaspore mother cells. × 825.

FIG. 20. Mitotic figure of first division of elongated primary sporogenous cell; cytoplasmic radiations about one pole. × 2000.

FIG. 21. Synapsis phase of the nucleus of the elongated primary sporogenous cell. × 2000.

FIGS. 22 and 23. The upper and the lower nucleus, respectively, of *fig. 18*, both in synapsis. × 2000.

FIG. 24. Apex of the nucellus with embryo sac after completion of first nuclear division. × 1300.

FIG. 25. The same after completion of second nuclear division. × 825.

FIG. 26. The same after completion of third nuclear division. × 625.

FIG. 27. Lower end of an embryo-sac showing the three antipodals, and fusion of the polar nuclei. × 1300.

FIG. 28. Embryo sac ready for fertilization. × 825.

FIG. 29. Apex of the embryo sac with pollen tube, striated synergids, and oosphere. × 1300.

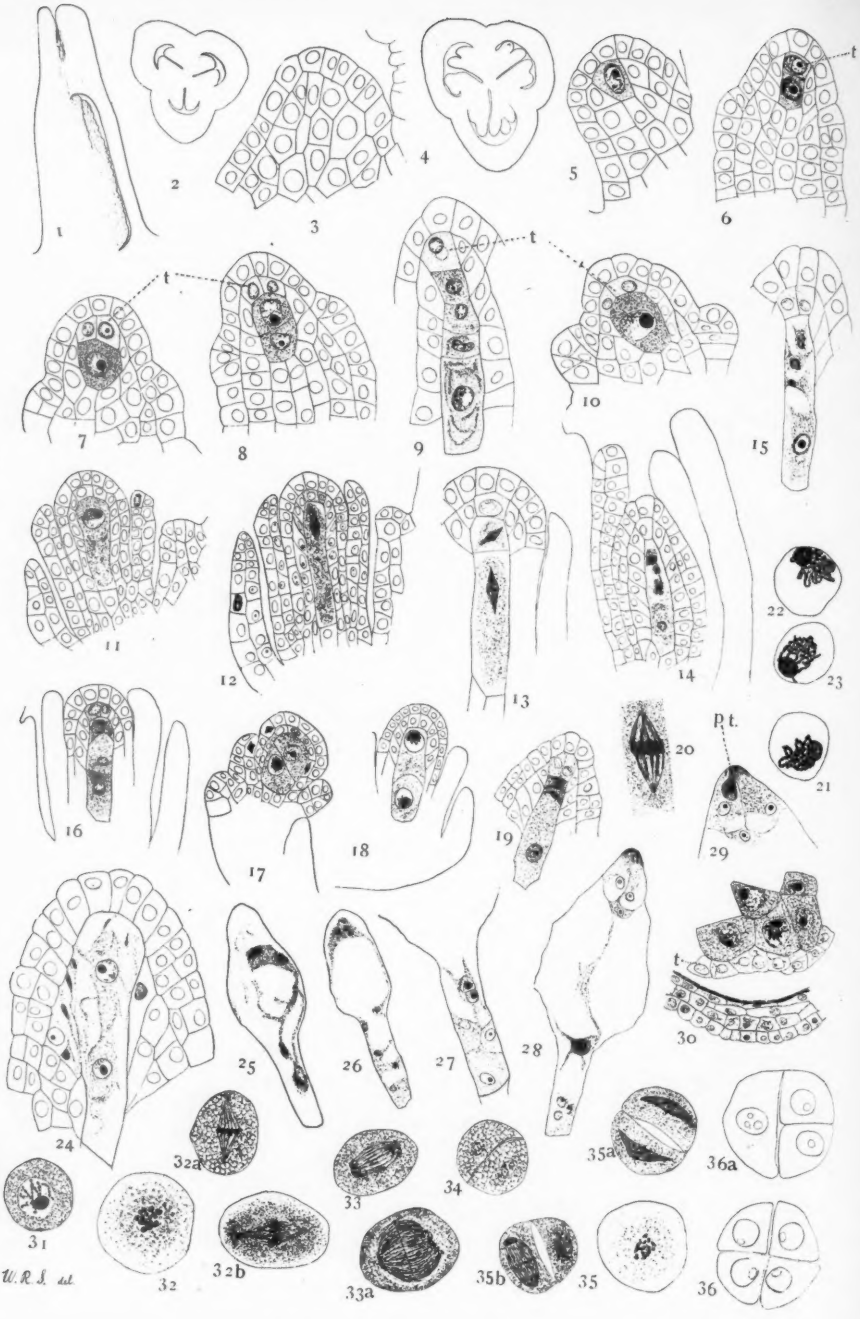
FIG. 30. Part of cross section of anther; *t*, the tapetum. Outside the tapetum a layer of disorganized cells may be seen. × 825.

FIG. 31. A single rounded pollen mother cell with its nucleus in the prophase stage. × 1300.

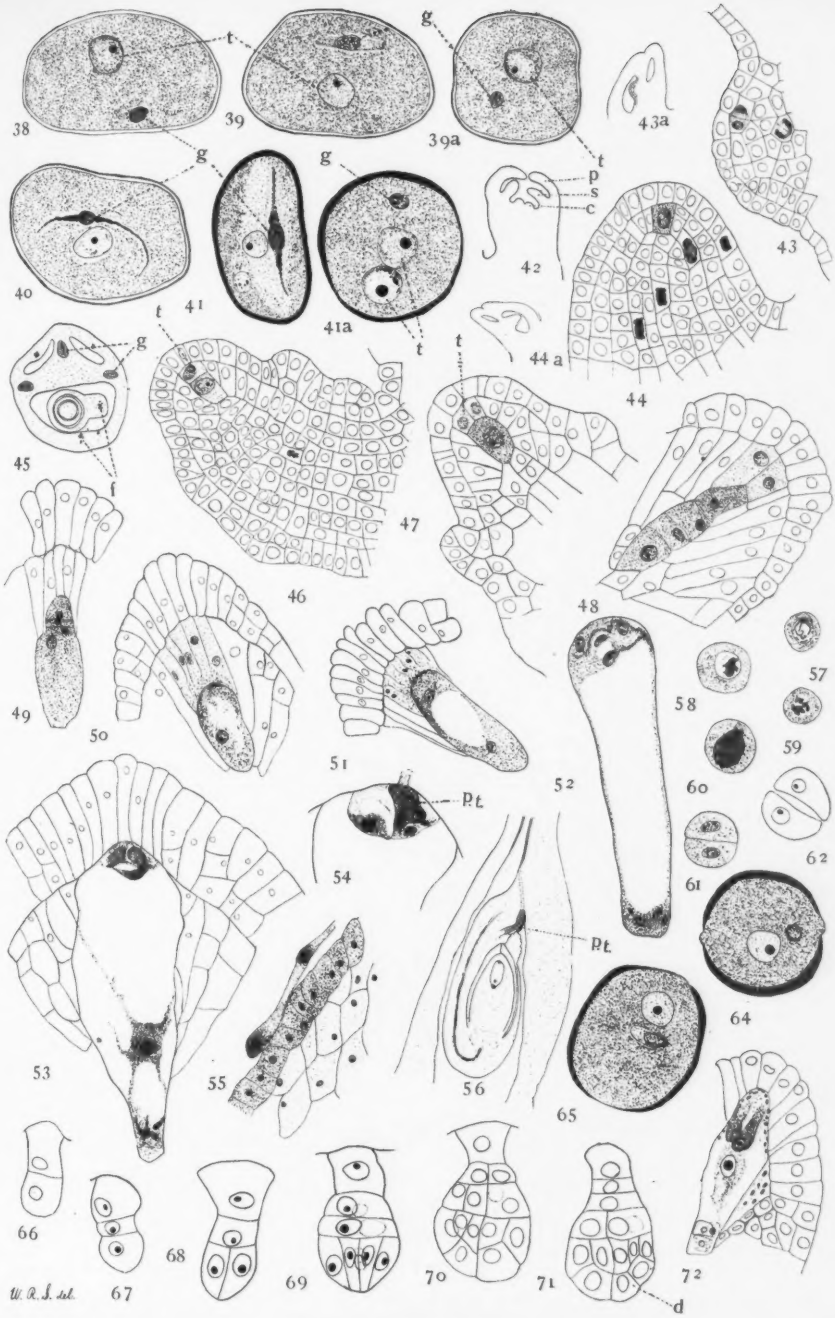
FIGS. 32–36*a*. Stages in the divisions of the pollen mother cell. *Fig. 32* shows the chromosomes in the equatorial plate of the first mitosis; *fig. 35* in the equatorial plate of the second mitosis. *Figs. 32a* and *35* × 1550; the others × 1300.

PLATE XX.

FIG. 38. A microspore showing first organization of generative cell (*g*). In this and the following figures the tube nucleus is denoted by *t*. × 1300.



SMITH on PONTEDERIACEÆ.



SMITH on PONTEDERIACEÆ.

FIG. 39. Longitudinal section of an older microspore with generative cell and tube nucleus. × 1300.

FIG. 39*a*. Cross section of microspore of same age as *fig. 39*. × 1300.

FIG. 40. Ripe microspore. × 1300.

FIG. 41. Longitudinal section of ripe microspore, with generative cell and two tube nuclei. × 1300.

FIG. 41*a*. Cross section of a similar microspore. × 1300.

Pontederia cordata.

FIG. 42. Longitudinal section of young flower; *p*, perianth, *s*, stamen, *c*, carpel. × 125.

FIG. 43. Ovule before the differentiation of the archesporial cell. × 1300.

FIG. 43*a*. Longitudinal section of ovary to show the relation of the ovule to the carpels.

FIG. 44. Young ovule with archesporial cell. × 1300.

FIG. 44*a*. Longitudinal section of ovary to explain *fig. 44*.

FIG. 45. Cross section of ovary, semi-diagrammatic; *f*, vascular bundles, *g*, glandular cavities.

FIG. 46. Young ovule with tapetal cell (*t*) and primary sporogenous cell. × 1300.

FIG. 46. Young ovule. The primary tapetal cell has divided into two. × 1300.

FIG. 48. Apex of nucellus with four megaspore mother cells. × 825.

FIGS. 49 and 50. Encroachment of megaspore upon the sterile mother cells. At this time both integuments have grown beyond the apex of the nucellus. × 825.

FIG. 51. Embryo sac with two nuclei. × 825.

FIG. 52. Embryo sac with eight nuclei. × 825.

FIG. 53. Embryo sac ready for fertilization. × 825.

FIG. 54. Apex of embryo sac with pollen tube. × 1300.

FIG. 55. Longitudinal section of part of style, showing pollen tube traversing a cavity lined with glandular cells. × 825.

FIG. 56. Longitudinal section of ovary showing ovule, conducting tissue, and pollen tube (*p. t.*). × 125.

FIGS. 57–62. Stages in division of microspore mother cell. × 1300.

FIG. 59. Chromosomes in equatorial plate of first mitosis of microspore mother cell. × 1300.

FIGS. 64 and 65. Mature microspores. × 1300.

FIGS. 66–71. Stages in the early growth of the embryo; *d*, dermatogen. × 1300.

Heteranthera graminis.

FIG. 72. Embryo sac ready for fertilization. × 1300.

THE GROUPS OF ANGIOSPERMS.[1]

A. ENGLER.

[IN the form of a supplement[2] to Parts II, III, and IV of *Die Natürliche Pflanzenfamilien*, Dr. Engler has presented a comprehensive review of the taxonomic divisions of spermatophytes. In it he has made important alterations in the sequence and structure of the series as arranged and delimited in the original work. In the light of results obtained since the publication of the earlier parts of the *Pflanzenfamilien*, a rearrangement has been made of which the following abstract from the author's "Erlauterungen" serves to give a general idea. Even the more important details have been rigidly omitted, and for a comprehensive grasp of the reasons for the changes the reader must be referred to the "key" which forms the skeleton of the supplement, and to the context.—EDS.]

The sequence of series and families is treated with special reference to the progressive steps which are manifested in floral structure, fruit and seed development, and differentiation of tissue.

Certain difficulties present themselves in the practical carrying out of such a scheme. It often occurs that within one circle of relationship a certain tribe has advanced in some particular direction, remaining latent in other directions, while the reverse may be true of other related tribes. In other cases it is doubtful whether certain lower stages are primitive, or whether they have arisen through reduction.

Eichler has recognized the so-called apetalous families of dicotyledons as haplochlamydeous, or naked-blooming, instead of abortive, and has placed them at the beginning of dicotyledons. To these I have added Piperales, Proteales, Santalales, and Aristolochiales.

[1] Abstract of translation prepared by Dr. Edwin B. Uline.

[2] ENGLER, A.: Übersicht über die Unterabteilungen, Klassen, Reihen, Unterreihen und Familien der Embryophyta siphonogama. Leipzig: Wilhelm Engelmann. 1897.

Before entering upon a discussion of the sequence of series in the monocotyledons and dicotyledons, I wish to speak of the diagnostic importance which is being laid upon the development of the pollen-tube in the ovule, and the structure of the ovule with respect to the development of the integuments. In the first few series of Archichlamydeæ (*i. e.*, the Piperales, Verticillatæ, Fagales, Juglandales, Myricales, Salicales, Urticales, Proteales, Santalales, and Aristolochiales) the pollen-tube and the ovules show relations which never occur elsewhere in angiosperms. As for the chalazogamy of Treub, the investigations of Nawaschin and others have greatly depreciated its importance from the standpoint of classification, and of late more importance has been laid upon the peculiar conditions which occur in the Santalaceæ and Loranthaceæ in the development of ovules and embryo sacs, as set forth by Van Tieghem, who distinguishes a phanerogamous division "Inovulées" to which the Loranthaceæ and Balanophoraceæ belong, and another division "Innucellées," which about corresponds to our Santalaceæ.

For my part, I do not see sufficient importance in either of these sets of characters to justify the establishment of subdivisions of the first rank. Nor in the fact that in the Loranthaceæ the embryo sac is developed within the tissues of the carpel do I discern peculiarities which justify setting these plants apart as opposed to the remaining dicotyledons and monocotyledons. I can only regard them as dicotyledons which, like all other dicotyledons, are opposed in many respects to monocotyledons, but which in the development of the ovules show certain departures of their own. We can no more found a higher systematic division on the more or less complete development of the ovule than on the presence of endosperm and perisperm; or on the more or less advanced development of the embryo of the mother-plant. Indeed, if the gymnosperms stand in close relation to the pteridophytes, since normally developed ovules with nucellus and integument occur in the gymnosperms, it is natural to assume that the peculiar development of ovules in the Santalales is merely a phenomenon of reduction.

But it is a striking fact that these departures occur in several of those families which were formerly known as apetalous. This seems the more reason why all these families should occupy a lower place in the system of dicotyledons. The manner of fertilization and the development of the embryo sac is here not so fixed as in the other dicotyledons. The Proteaceæ, also, which I have placed much lower than Eichler, show a striking departure from other dicotyledons in that the number of cotyledons may reach even eight.

MONOCOTYLEDONS.

Among the nonocotyledons those series in which typical achlamydeous flowers occur represent the earliest stages of development. These are the Pandanales, Helobiæ, and Glumifloræ. Of these the Pandanales are most primitive, because of indefiniteness of floral parts, and the spiral arrangement of stamens. Whether the Helobiæ or the Glumifloræ stand next in order is difficult to decide. Owing to the great instability prevailing in the Helobiæ, I have preferred to let them precede the Glumifloræ, and have left the Gramineæ and Cyperaceæ together in Glumifloræ.

Common to the three series Principes, Synanthes and Spathifloræ is the appearance of a floral envelope, which in some cases is suppressed by the more vigorous development of the spathe.

Several subseries under the Farinosæ must be set apart; notably the Flagellariineæ, which do not affiliate closely with any other family. The subseries Enantioblastæ is characterized by its orthotropous ovules, while the remaining Farinosæ have anatropous ovules.

Most of the Liliifloræ belong to the subseries Liliineæ. I have regarded the Juncaceæ as a separate subseries, Juncineæ, being intermediate in the structure of their albumen between the Farinosæ and the Lilliifloræ. Likewise I have separated the Iridaceæ as subseries Iridineæ, basing it upon the leafy development and division of the style branches, as well as upon the position of the leaves.

I believe it a misconception to regard the Scitamineæ as direct descendants of the Liliaceæ or of the Amaryllidaceæ. Though the Scitamineæ do resemble Dracæna and Cordyline, stronger characters argue against deriving them from the Liliifloræ, viz., the formation of endosperm and perisperm, the smooth exine and thick intine of the pollen grains, the presence of simple and complex starch grains in the albumen.

The Microspermæ comprise the Burmanniaceæ and Orchidaceæ, whose relationship to each other is based solely upon the numerous small ovules and the parietal placentation. The Burmanniaceæ are like the Orchidaceæ in that they attain a degree of zygomorphism which is found in few monocotyledons, and a careful review of characters shows no possible connecting link between Orchidaceæ and the Liliifloræ. The Microspermæ may fall, therefore, into the two subseries, Burmanniineæ and Gynandræ.

DICOTYLEDONS.

The dicotyledons as here presented show many departures from Eichler's system. One of the most essential changes is the breaking up of the series of Amentaceæ and the interpolation at various places of the miscellaneous families designated by Eichler as Hysterophyta. That the Amentaceæ of Eichler do not represent one circle of relationship has become apparent after close investigation of the ovules and the processes of fertilization. That the establishment of the Hysterophyta was only provisional is evident from their long-known variability as to the gynæceum.

The Ceratophyllaceæ are taken out of Eichler's Urticinæ and placed near the Nymphæaceæ; the Piperaceæ are separated from the Polygoninæ; the Droseraceæ, Sarraceniaceæ and Nepenthaceæ are separated from the Cistifloræ or Parietales as Sarraceniales; the Passiflorinæ are brought under the series Parietales; the series Terebinthinæ and Tricoccæ have been entirely broken up and their separate families referred partly to the Geraniales, partly to the Sapindales or to the Æsculinæ, the

limitation of these latter two series being governed by the orientation of the ovules, a scheme used also by Bentham and Hooker ; the series Frangulinæ or Rhamnales has been restricted to the families Rhamnaceæ and Vitaceæ, while the Aquifoliaceæ, Celastraceæ and Hippocrateaceæ are put in Sapindales. I follow Pax and Baillon in placing the Pittosporaceæ near the Saxifragaceæ. I have united the series Saxifraginæ, Rosifloræ, and Leguminosæ into one series, *i. e.*, the Rosales, since the natural affinity of these groups is beyond all doubt. The Proteaceæ have been excluded from the Thymelæales and placed more toward the beginning of the system near the Santalales, the remaining families being added to the Myrtifloræ or Myrtales.

Of the Sympetalæ the two series Tubifloræ and Labiatifloræ are united ; the Aggregatæ on the other hand are broken up, and the Valerianaceæ together with the Dipsacaceæ placed in the Rubiales, and the Compositæ in the Campanulatæ.

Both subclasses of dicotyledons, Archichlamydeæ and Sympetalæ, are retained, although sharp distinctions between them do not exist. The guiding characters for the disposition of the series under the Archichlamydeæ are chiefly the development of the perianth, the floral axis, and the arrangement of floral parts, but consideration has been given also to the make-up of the ovules in so far as the Casuarinaceæ are concerned, distinguished by numerous megaspores, and for which alone the series Verticillatæ has been made, and is placed at the beginning of the Archichlamydeæ.

Of the remaining series, those which have no perianth must take the lowest place, namely, first the Piperales, then the Salicales, then the Myricales, in which several bracts near the flowers often take the place of a perianth. The Myricales contain only the Myricaceæ, which with the Juglandaceæ I had placed formerly under the Juglandales.

The Balanopsidales with the family Balanopsidaceæ represent an isolated series which occupies a very low place by reason of the rudimentary perianth of the staminate flowers, and the bracteate envelope of the pistillate ones.

The series of Leitneriales with the Leitneriaceæ is doubtful, since we may have to do here with a reduced type. If such were once shown, then this family would come next to the Hamamelidaceæ, near the Rosales.

The Juglandales occupy a higher position, nearly always possessing a perianth, which in the pistillate flowers is coalescent with the carpels, giving rise to apparent epigyny. The Juglandales are further distinguished from the Myricales by chalazogamy, but whether this character is constant must yet be determined.

The Fagales show the same stage of progress as the Juglandales. Coordinate with the Fagales are the Urticales in which the Ulmaceæ precede the Moraceæ and Urticaceæ because of the occurrence of hermaphrodite flowers.

In the Proteales the perianth is sometimes green, but in the majority of cases it is petaloid, but a differentiation of calyx does not appear. This series is easily distinguished from the Santalales by its single free carpel with ventral placentation.

The Santalales, comprising the Loranthaceæ, Myzodendraceæ, Santalaceæ, Grubbiaceæ, Opiliaceæ and Balanophoraceæ, have their gynæceum made up of three (more rarely one or two) carpels, and for each carpel but one embryo sac is developed.

In the Aristolochiales the petaloid segments of the perianth become more or less coalescent, and the carpels are provided with an indefinite number of ovules and an inferior ovary.

The Polygonales form, in certain respects, the transition stage to the Centrospermæ, though the latter is characterized by the presence of perisperm.

Although it is mentioned above that certain series are morphologically further advanced than others, and that on the other hand certain series as the Fagales and Urticales occupy the same morphological stage of advancement, yet each of these series is to be regarded as an independent plant-group, which can in no sense be derived from any of the others. Nor is there any reason to suppose that any of these series constitute a point of divergence for the following series.

In the Centrospermæ heterochlamydy occurs frequently, though it does not yet dominate. The Chenopodiaceæ and Amaranthaceæ form one branch of the series, while the Nyctaginaceæ, Cynocrambaceæ, Batidaceæ, and Aizoaceæ together with the Phytolaccaceæ, in certain respects the center of development, form another branch. Of these the Nyctaginaceæ have reached a higher stage than the Chenopodiaceæ and Amaranthaceæ in that the simple corolla is made of petaloid coalescent segments. The Cynocrambaceæ and Batidaceæ form isolated types which, in common with Phytolaccaceæ, still retain one-ovuled carpels. The Phytolaccaceæ, having free or slightly united carpels, would occupy a low position, save for the appearance of heterochlamydy and cyclic flowers. Still a third subseries is formed by the Basellaceæ and Portulaccaceæ; a fourth by the Caryophyllaceæ.

Of the numerous heterochlamydeous series the first is Ranales, characterized by predominating apocarpy and hypogyny. It has preserved a strong tendency to the spiral arrangement of floral parts, but heterochlamydy is much more frequent than in the Centrospermæ, and zygomorphism occasionally occurs. At least four subseries are to be distinguished. The Nymphæaceæ and Ceratophyllaceæ form the first; the rather isolated Trochodendraceæ the second; the Ranunculaceæ, Lardizabalaceæ, Berberidaceæ, and Menispermaceæ, the third. This third subseries has a probable common origin very near the Nymphæaceæ. The fourth comprises the Magnoliaceæ, Lactoridaceæ, Anonaceæ, Myristicaceæ, Gomortegaceæ, Monimiaceæ, Lauraceæ, and Hernandiaceæ, all characterized by the presence of oil cells. I have named these subseries respectively the Nymphacineæ, Trochodendrineæ, Ranunculineæ, and Magnoliineæ. In the three larger, which are further advanced than Trochodendrineæ, there occurs the change from spiral to cyclical flowers.

Since in the Ranales the spiral arrangement, indefinite numbers of parts in androœceum and gynæceum, and apocarpy all appear as dominating characters, it is clear that the other series

diverge from the Ranales in various ways, some following one direction of development, some another.

The Rhœadales have long been recognized to be closely related to the Ranales, for the Papaveraceæ show analogies with the Nymphæaceæ in their mostly numerous stamens, and in the occasional occurrence of several (though united) carpels in the gynæceum.

The Sarraceniales furnish a parallel series to the Rhœadales. This series shows much in common in the arrangement of floral parts with the Nymphæaceæ and Papaveraceæ. The placentation in the Sarraceniaceæ is the principal character distinguishing the series from the Rhœadales.

I have considerably extended the Rosales, which very often have apocarpy and hypogyny or perigyny in common with the Ranales, but more often show syncarpy and epigyny. The series comprises the Saxifragineæ, the Rosifloræ, and the Leguminosæ of Eichler. We have never been able to discover a comprehensive distinction between the Rosaceæ and Saxifragaceæ; nor is there any dividing line between the Rosaceæ and the Leguminosæ sufficient to warrant putting them in separate series. It may seem strange that the Podostemonaceæ stand at the beginning of Rosales, but Warming has shown their connection with the Saxifragaceæ on the basis of floral structure. The Leguminosæ and the Connaraceæ are to be regarded sister-families of the Rosaceæ, since the families of Rosales are, as a whole, so nearly related that it is difficult to conceive of them under subsections. The Saxifragineæ, however, form a center of development, from which the Podostemonineæ branch in one direction, the Rosineæ in another.

In both the Geraniales and the Sapindales the cyclic arrangement of floral parts is complete, but the still imperfect union of the carpels is a ground for placing both series before the Malvales and Parietales. The two series may only be distinguished by the ovule characters. In the Geraniales the Geraniaceæ and the Oxalidaceæ are followed by the zygomorphous and oligomerous Tropæolaceæ. I have then followed with the Zygophyl-

laceæ, which occupy mostly the same plane as the Geraniaceæ, but in the other direction they approach very near to the Cneoraceæ, Rutaceæ and Simarubaceæ. Since the Rutaceæ are intimately connected with the Simarubaceæ, Burseraceæ and Meliaceæ, it is possible to conceive of these families all together as Geraniineæ. Morphological advance in another direction is seen in the Malpighiineæ. It is expedient also to distinguish the Polygalineæ, Dichapetalineæ and Tricoccæ as subseries, which possess scarcely any surviving common features.

In the Sapindales, considering the entire organization, foliar arrangement and anatomy, we are forced to establish a large number of subseries. At the first are the Buxineæ, provided that the simple perianth is primitive rather than reduced. The Empetraceæ, Coriariaceæ, and Limnanthaceæ occupy similar rank in the character of perianth and the number of ovules, but are withal so distinct that each family must be regarded as the representative of a subseries. The resinous Anacardiaceæ may be regarded as an independent subseries coordinate with and opposed to the Celastrineæ and Icacineæ. The Sapindaceæ comprise the closely related Aceraceæ, Hippocastanaceæ and Sapindaceæ, and the Sabiineæ, Melianthineæ and Balsaminineæ. The setting apart of so many subseries shows there is no sufficient ground for the derivation of the more complex families of the series from the simpler.

The Rhamnales are now confined to the tetracyclic Archichlamydeæ with opposite stamens.

As in the Geraniales and Sapindales, there are to be found in the Malvales distinct or slightly united carpels, but in the latter case complete syncarpy prevails. I justify my letting the Malvales follow the Geraniales, Sapindales, and Rhamnales by the close relationship of the Elæocarpaceæ and the Chlænaceæ to the Parietales, within which the floral evolution has already reached very complicated floral types. The Malvales clearly show how a family may reach in certain directions a considerable stage of development, while in others it remains far behind. Conditions are present which show that the near related families

of the series are coordinate and not serial; that they stand side by side, but have not proceeded one from another. The Scytopetalaceæ have a very uncertain position in the series.

As already indicated, the Parietales reach back in their affinities through their simpler families to the region of the Ranales. The Dilleniaceæ were also formerly reckoned with the Ranales, but they show affinities for the tropical families Eucryphiaceæ, Ochnaceæ, Caryocaraceæ, Marcgraviaceæ, Quiinaceæ, Theaceæ, Guttiferæ, and Dipterocarpaceæ, and I have brought them all together as a subseries, Theineæ. Another subseries, the Tamaricineæ, is made up of the Elatinaceæ, Tamaricaceæ, and Frankeniaceæ, which mostly inhabit temperate zones. The Fouquieriaceæ, which in the *Pflanzenfamilien* were reckoned with the Tamaricaceæ, are better separated as an independent family and subseries, on account of their gamopetalous corolla and oily albumen. The changes which have been made in this series are based chiefly upon the results obtained by Dr. Pritzel in his late studies of the seeds of Parietales. His data have great value in the determination of the genetic relationships. Such a series as the Parietales is not to be regarded as a single monophyletic circle of relationship, but as a complex of such circles, which, proceeding from various starting points, have either arrived in their evolution at the same morphological stage of advancement, or, like the subseries Flacourtiineæ, still show various stages of development.

The Opuntiales, with their spiral floral arrangement and tubular receptacle which encloses the syncarpous gynœceum, show quite a primitive floral type, essentially departing very little from that of many Nymphæaceæ. The only reasons for placing this series next the Parietales is that free carpels never occur in the Cactaceæ, that the placentæ are parietal, and the styles are united.

In the series Myrtifloræ and Umbellifloræ the envelopment of the gynæceum within the receptacle has become the rule, and, in contrast to the preceding series, the arrangement of stamens is constantly cyclic. In the Myrtifloræ perigynous and epigy-

nous insertions prevail; in the Umbellifloræ only the epigynous occurs. The series Thymelæales, which formerly, following Eichler, I placed next to the Myrtifloræ, I now believe to be only a subseries of the latter. In those families formerly regarded as Thymelæales perigyny, tetramery, a tendency to apetaly, and a small number of ovules in the carpels prevail, but every one of these characters also occurs in the Myrtifloræ. The Halorrhagidaceæ and the Cynomoriaceæ I regard as representatives of an independent subseries, whose flowers show a most remarkable agreement with Hippuris. That the Umbellifloræ belong at the end of the Archichlamydeæ is certain by reason of their one-ovuled carpels and mostly reduced sepals. The close interrelationship of the three families belonging here is without question.

The opinion has often found expression that the Sympetalæ may be only monopetalous. This cannot be the case, and it is equally certain that the various series of the Sympetalæ are not to be regarded as a continuation of the Archichlamydeæ. When sympetaly arose in prevailingly archichlamydeal series, such sympetalous genera were naturally placed in archichlamydeal families. The subclass Metachlamydeæ or Sympetalæ thus comprises those families in which connate petals have become the rule. Just as the series indicates the stage at which certain genetic subseries have arrived, so the subclass Sympetalæ may be looked upon as a stage for morphologically further advanced series.

The Ericales and Primulales belong at the beginning of the Sympetalæ, for here distinct petals still occur, and two staminal whorls are typical, whereas in the remaining series, with the exception of the Ebenales, only one staminal whorl is developed.

The Ebenales are distinct from the Ericales in that the flowers are not obdiplostemonous, but diplostemonous or triplostemonous, or they may contain numerous stamens. They differ from the Primulales in the septation of the ovary, and from the remaining series in the possession of more than one staminal whorl.

The Contortæ are by no means to be sharply distinguished from the next comprehensive series, Tubifloræ. It is simply a question of differing tendencies of development. One subseries, the Oleineæ, with the families Oleaceæ and Salvadoraceæ, sometimes still possesses distinct petals. In the second subseries, the Gentianineæ, belong the Loganiaceæ, Gentianaceæ, Apocynaceæ, and Asclepiadaceæ, the first of which comprises genera which show characters common also to the three other families, but also contains genera which lean more toward the Tubifloræ and Rubiales. The Loganiceæ may thus represent an older type, from which the other families of Gentianineæ, and perhaps the Rubiales, have branched off.

The largest and most difficult series is the Tubifloræ, within which numerous families are separated from one another only by very poorly defined characters. Advancement takes place from those families with actinomorphous flowers and several-ovuled carpels to those with zygomorphous flowers and few-ovuled carpels. But in a part of the Tubifloræ the tendency to claw-formation especially prevails, and in these the carpels contain only a few, often only two ovules. In close connection with these Tubifloræ are the Hydrophyllaceæ and Convolvulaceæ. Therefore, I distinguish first the subseries Convolvulineæ, with the Convolvulaceæ and the Polemoniaceæ. The Borragininеæ constitute the second subseries, of which the Hydrophyllaceæ possess capsules and may be regarded as the starting point for those Borraginaceæ which possess claw-fruit. The subseries Verbenineæ joins on to the Convolvulaceæ by having in the Verbenaceæ and the Labiatæ the ovule with the micropyle directed downward. Then come the numerous families which group themselves about the Solanaceæ and Scrophulariaceæ in which placentæ with numerous ovules mostly occur. These I have grouped together under the subseries Solanineæ. Between them and the Convolvulineæ are the Nolanaceæ. The Acanthineæ belong near the Solanineæ, yet owing to the great number of peculiarities of the Acanthaceæ, and in spite of certain points in common with the Bignoniaceæ and Scrophulariaceæ, I have ventured to separate them as a subsection.

Some botanists might prefer to put the Plantaginales under the Tubifloræ, but in that case, on account of the upturned micropyle, they would form a special subsection near the Borragineæ. I have placed them next the Tubifloræ as an independent series.

The epigynous Rubiales and Campanulatæ form naturally the close of the Sympetalæ. In both series we find actinomorphy and capsules with numerous ovules; in both series the further stages of zygomorphy and reduction are reached.

In the series Rubiales, to which, following Fritsch and Hoeck, I have added the Valerianaceæ and Dipsacaceæ, I do not regard division into subseries as necessary. Both the families just named join quite closely to the Caprifoliaceæ. We can only venture to offer a special subseries for the peculiar Adoxaceæ.

In the Campanulatæ, on the contrary, the Cucurbitaceæ occupy a special place, and form the subseries Cucurbitineæ. The Campanulaceæ must be regarded as the remnant of a trunk from which the others have branched out. That the Compositæ occupy the last place in the system can scarcely any longer be doubted.

It is evident that the several series are independent form-groups which have developed mostly side by side, but not from one another. In only a few cases do the series stand so near together that a common origin must be supposed. The same is true also of the subseries and of the families within the subseries. Even within the families themselves it is mostly not possible to determine a common starting point for the subfamilies. In spite of all the uncertainty that prevails regarding the origin of series, it is absolutely certain that parallel development has very often taken place, and the view that in the development of the siphonogams from the asiphonogams a great number of parallel series came into existence from the beginning seems tenable. The oldest monocotyledons and dicotyledons, like the living conifers and other gymnosperms, possessed no floral envelope, but an indefinite number of stamens and carpels, which were either spiral or whorled within the

same tribe. Then from the bracts preceding these sexual phyllomes, or from the lowest stamens, the perianth was developed. In a few scattered tribes of monocotyledons and dicotyledons these lower stages are still to be found, but in others, where cyclical arrangement and definite numbers prevail, they have disappeared. We cannot know whether or not the latter possessed spiral arrangement of members originally; indeed, it is not necessary that this should have been the case, for it is possible that at the very first formation of series, forms with spiral and also with cyclical arrangement should have arisen. Thus fixation of number could have appeared early in the one and late in the other.

Nägeli believed that every tribe has proceeded from early types with spirally arranged floral phyllomes. If this were true, then the Orchidaceæ, for instance, would be the oldest of monocotyledon types, and the Umbelliferæ and Compositæ very old types of dicotyledons, for they would have gone through the most modifications. However, in my opinion, there is nothing against the view that cyclical arrangement arose in certain tribes from the very beginning. In the most of these tribes and series fixation of number probably appeared very early, and of these many afterward suffered modifications by reduction of particular members or multiplication of others. In those series in which wind-pollination prevailed, Pandanales, Glumifloræ, Principes, Fagales, a highly developed corolla, having no particular value, stood no chance of transmission to the generations following. Modifications could only take place in other directions, particularly in the reduction of the number of members, which in certain Glumifloræ, Piperaceæ, Salicaceæ, Urticaceæ, and Chenopodiaceæ has reached its extreme limit. Or modifications may also occur in the form of complex inflorescence. But where the perianth is petaloid and insect-pollination has become established, finally zygomorphy follows, and thereby reduction, which attains considerable importance in such families as the Pontederiaceæ, Leguminosæ, Philydraceæ, Rutaceæ, etc. Although in the reduction of petaloid and hetero-

chlamydeal flowers I have ascribed much influence to insect-pollination, yet I must contend against the opinion that the formation of petaloid structures has been induced by insect-pollination. The appearance of these structures in various and widely separate series can at first only have been conditioned upon external influences. In countless culture plants we see that by supplying richer nutrient materials and more light the formation of petaloid structures notably increases, and that sepals and stamens become petaloid. But it is to be conceded that insect visits may contribute to the fixation of such characters when once acquired, but they alone could not accomplish this were the physiological causes of color supply not permanently furnished to the succeeding generations. The development of color material in the floral phyllomes may also be retarded by its transference to the subtending bracts or to other more favored flowers in the inflorescence. In the Spathifloræ the development of the flowers remains in the background, owing to the manifold capabilities of the spathe, while the petaloid bracts of Dalechampia in the Euphorbiaceæ produce the same result. The inner flowers in the inflorescence of Hydrangea are retarded by the strong petaloid development on the periphery. On the other hand, insect-pollination is decidedly instrumental in the reduction of flowers, more than in the special petaloid development of particular perianth-whorls. For it is quite clear that when the insects continually prefer in their visits those stamens or carpels most conveniently situated, those not used must gradually become functionless. Here it is not a question of production of certain materials, as in the case of the petaloid perianth, but only of restriction or suppression of already existing structures at the expense of other more vigorous ones.

Among the monocotyledons the Scitamineæ and Microspermæ surpass all others in the production of petaloid floral parts, in the prevalence of zygomorphy, and in the reduction of the andrœceum. In the dicotyledons these conditions appear in a great number of series.

BERLIN.

BRIEFER ARTICLES.

THE WILD FLOWERS OF CUSHING'S ISLAND, MAINE.

THE popular summer resort known as Cushing's island is a small island in Casco bay, a few miles from the city of Portland. Its greatest length is a mile and a quarter, and its shore line about five miles. In shape it is roughly triangular; the base of the triangle, or the back of the island, is towards the open ocean, while the front looks towards the mainland and Portland city.

A rocky ridge runs through the island close to its seaward side, projecting as "The Point" at one extremity, and forming White Head cliffs at the other. This ridge, covered with a stiff growth of spruce and fir trees, forms a very efficient protection to the rest of the island from the storms and cold winds from the ocean. The large hotel known as the Ottawa House is situated on one of the highest parts of this ridge, and looks over the landward half of the island, which is low and rather level, with grassy meadows and sandy shores.

On account of this conformation of the ground, there is an unusual diversity of natural conditions. Hence, in spite of the small size of the island, there is an astonishing variety of wild flowers to be found; so that the writer was able to gather in the course of a short summer's vacation more than three hundred distinct species, and there are doubtless many others which escaped his attention.

The first place to which a visitor to the hotel would naturally turn his attention is the woods which lie immediately behind it. As intimated before, these woods are formed almost entirely of spruce and fir trees, and this fact alone will enable any botanist to picture them in his mind. Such woods are always cool and shady, even on the hottest summer day, with dark foliage overhead and the pleasant odor of balsam in the air. Little underbrush is formed owing to the dense shade of the thick branches, but the ground is covered with a soft carpet of moss and fir needles. Everywhere are to be seen the delicate graceful fronds of the wood-ferns, the dark leaves of the wintergreen

(*Gaultheria procumbens*), or the bunch-berry (*Cornus Canadensis*) with its red berries. There are other forms more difficult to find, but which will amply repay a search for them. Few of our native flowers can be compared with the twin-flower (*Linnæa borealis*), whose slender creeping vines and tiny pink bells sometimes completely cover the ground and scent the woods for yards around. In certain nooks may be found clusters of lady's slippers (*Cypripedium acaule*), one of the most beautiful of our orchids, or the white waxy flowers of the shin-leaf (*Pyrola rotundifolia*), or the delicate enchanter's nightshade (*Circæa alpina*).

In certain parts of the woods there are low places, where the ground becomes swampy. Here the undergrowth becomes more profuse. The magnificent flowering ferns or osmundas, growing to a height of four or five feet, often form dense brakes. The curious Jack-in-the-pulpit (*Arisæma triphyllum*) abounds, and rarer forms such as the rein-orchis (*Habenaria bracteata*) and the ragged fringed orchis (*Habenaria lacera*) are found; while in the soft moist swamp-moss are growing more delicate plants, such as the sweet white violet (*Viola blanda*), the small bedstraw (*Galium trifidum*), and many others.

Some years ago a fire occurred on the island, and burned off a large tract of woodland along the White Head road, between the hotel and the Ross cottage. Light and sunshine having been let in on the ground plants of all kinds seem to have invaded the place and to be struggling for its possession. A new growth of poplar and white birch is springing up and promises to take the place of the former dark conifers. At present, however, another group of plants is in the ascendancy, for this clearing is the home of the berries for which Cushing's island is famous. Every summer numerous parties of berry pickers visit the island and return laden with fruit, but their depredations seem to have little effect in exhausting the supply. Raspberries and blue berries are the most abundant, but there is no lack of blackberries, gooseberries, and huckleberries. The plants also are very varied, each week during the summer showing a new assortment. Bushes of elder (*Sambucus Canadensis*) and viburnum (*Viburnum cassinoides*), covered with white blossoms, are perhaps the most showy. The great willow-herb (*Epilobium angustifolium*) is common, as is usual on all burnt ground. Other plants that are particularly noticeable are golden ragwort (*Senecio aureus*), sarsaparilla (*Aralia hispida*), hawkweed (*Hieracium scabrum*), cow-wheat (*Melampyum Americanum*), and ladies' tresses (*Spiranthes gracilis*).

Leaving the wooded ridge that shelters the island from the ocean,

we come next to the landward side. This part of the island is more level and is occupied by meadows, with the cultivated fields belonging to the farm in the center of the island. It is here that the greatest abundance of summer flowers is to be found. In the spring violets and wild strawberries abound; later on, the meadows are a blaze of yellow and white from the buttercups and daisies which fairly cover the ground; still later, when the hay has been gathered in, and the fields have been left bare by the mowing machine, every stony place, hedge or thicket is adorned with masses of goldenrods and purple asters. Besides these plants, which are in such abundance as to form prominent features in the landscape, there are scores of old friends to be found by every roadside, along the fences, and among the hay. Here are clovers, everlastings, wild rose, sweetbriar, silkweed, thistles, mustard, evening primrose, and a host of others too numerous to be enumerated here. One point of interest might be mentioned in connection with these meadow plants. A botanist looking at the list of the species that occur would probably be struck by the fact that very few of them are native American plants. Cushing's island has been inhabited for two hundred and fifty years, and during this time many plants have been introduced, either intentionally or accidentally, through their seed being mixed with that planted on the farm. Other seeds have probably blown or floated across from the mainland. These foreigners have flourished and driven out of the fertile places most of the native plants; so that if one wishes to study true American plants, he must go to the woods, rocks, marshes, and out-of-the-way places. As an illustration of this it may be remarked that no less than fifty-eight different kinds of English, European, and tropical plants are to be found growing in the fields on Cushing's island.

Although the woods and meadows furnish the greater part of the wild flowers of the island, a visiting botanist would probably be more interested in the plants of a less promising locality, namely, those found on the rocky shores and sandy beaches. While the flowers already mentioned may be seen anywhere in the northern states, those of the shores are peculiar and only to be found along the Atlantic seaboard. They grow in the most unlikely localities, flourishing in the clefts of the rocks and in the dry sand down to and even below the high-tide mark. Few of them have showy blossoms, though the flowers of the beach pea (*Lathyrus maritimus*) and the Scotch lovage (*Ligusticum Scoticum*) are exceptions to this rule. More curious and charac-

teristic forms are the spiny saltwort (*Salsola Kali*), or the cactus-like samphire (*Salicornia herbacea*). Most of them have fleshy succulent stems and leaves, enabling them to store up the scanty moisture for a time of drought. This is well seen in the case of the sea blite (*Suæda linearis*), the sea rocket (*Cakile Americana*), and the seaside plantain (*Plantago maritima*). Other interesting plants found in these sections are the seaside crowfoot (*Ranunculus Cymbalaria*), goldenrod (*Solidago sempervirens*), sea lavender (*Statice Limonium*, var. *Caroliniana*), spurge (*Euphorbia polygonifolia*), rush saltgrass (*Spartina juncea*), and sea sand-reed (*Ammophila arundinacea*).

Besides the localities already mentioned, there are several natural features of Cushing's island which are especially interesting from a botanical standpoint. At the front of the island are two small marshes, separated from the sea only by narrow sandy beaches. These marshes are partly covered with dense thickets of hazel and alder, but the open parts furnish many interesting forms. As is usual in marshy places, reeds and sedges abound, with bulrushes, bur reeds, and irises. Certain parts of the marshes are carpeted with the delicate trailing vines of the cranberry (*Vaccinium macrocarpon*). Another plant of great interest found here is the sundew or flycatcher (*Drosera rotundifolia*), whose small leaves may be seen with all their glistening bristles spread out, ready to entrap any unwary insect.

Another characteristic feature of the island is the part called Bayberry ridge. This is a low ridge or rather a rise in the ground, which presents a rather peculiar appearance owing to islands of bushes which are scattered over it. These little islands are formed mainly of bayberry, sweet fern, and juniper bushes, but mingled with them are other flowering shrubs, such as blackberry bushes, wild roses, and spiraea.

The island terminates towards the north in a precipitous cliff known as White Head. Here the rocks rise perpendicularly from the sea to a height of over a hundred feet. Even on the face of this frowning rock, exposed to all the winds and storms, with nothing but tiny crevices for their support, are seen some of the most delicate plants. Prominent among these is the wild columbine (*Aquilegia Canadensis*), whose red and yellow blossoms are a familiar sight in such localities. An equally pretty but less showy flower is the crane's-bill (*Geranium Robertianum*). The lion's foot (*Prenanthes Serpentaria*) and some slender ferns and grasses complete this little group of hardy cliff-dwellers.

Lastly, no account of the flora of the island would be complete without some mention being made of the famous willow grove, a group of fifty or sixty magnificent trees growing in a slight hollow above the bathing beach. These trees are probably a hundred and fifty years old, many of them have trunks eighteen or twenty feet in circumference, and none of them show any signs of decay. Taken as a whole, it is probably the finest willow grove in the New England states.

This too brief and imperfect account may serve to give some idea of the flora of Cushing's island. A botanist could wish for no better place in which to study the flora of the northern New England coast. —HAROLD B. CUSHING, *Montreal, Canada.*

NOTES ON THE BOTANY OF THE SOUTHEASTERN STATES. II.

DIERVILLA RIVULARIS Gattinger, Bot. Gaz. **13**: 191. 1888.—Fruiting specimens of this interesting Diervilla were collected August 24 and again October 5, 1897, on the rocky bluffs of Lookout mountain, Tennessee. Dr. Gattinger originally found the species in a similar location at Lula falls, on the Georgia side of Lookout mountain, and some six miles from the station of the material at hand.

CRATÆGUS COLLINA Chapm. Flora S. U. S. ed. 2. second suppl. 684. 1892.—A species very distinct, but confounded with *C. punctata* Jacq. *C. collina*, as it grows at Biltmore, N. C., is a small tree 4–5^{m} in height, and with a trunk diameter of 1^{dm} under favorable conditions, with gray spreading branches that are freely armed with rather stout chestnut-brown to gray spines. The flowers, which appear before any others of the genus, are about 2^{cm} in diameter, white and of a disagreeable odor: calyx divisions lanceolate, glandular, the tube pubescent: shoots, foliage, and corymbs appressed pubescent, becoming glabrous with age: fruit globose, about 1^{cm} in diameter, dull red: leaves obovate to nearly oval, 3–7^{cm} long, including the petiole, 2–5^{cm} wide, or a trifle larger on vigorous shoots, acute, finely but obtusely serrate and incisely lobed, the base narrowed into a short petiole. The range, though imperfectly known, is evidently from northern Georgia, Tennessee, and North Carolina to West Virginia and Missouri. From *C. punctata* the species may be separated by the fewer

(4 or 5 pairs) and less prominent veins of the leaves, shorter petioles, and more abruptly attenuate base of the blades, earlier time of blossoming, glandular calyx lobes, and smaller fruit.

Fraxinus Biltmoreana, n. sp.—A tree 10–18^{m} in height, the trunk not often over 3^{dm} in diameter; branches large and spreading; branchlets stout, the growth of the season softly and densely pubescent: leaves 2 to 3^{dm} long, oblong to oval in outline; leaflets 7 to 9, ovate to oblong-lanceolate, acuminate, sometimes falcate, rounded, attenuate or inequilateral at the base, entire or obscurely denticulate, dark green and slightly lustrous above, below whitened and from sparsely to copiously pubescent, especially along the veins; petioles and petiolules finely and densely pubescent to puberulent: samaras, which are borne in open pubescent to nearly glabrous panicles, large, 3.5 to 5^{cm} long, the wing about 6^{mm} wide and from two and a half to three times longer than the elliptical, unmargined, many-nerved body. Flowers not collected.

The species evidently bears about the relation to *F. Americana* L. that *F. Pennsylvanica* Marsh. exhibits to *F. lanceolata* Borck. From *F. Americana* the Biltmore ash may be distinguished by the velvety twigs and petioles, the clove brown buds and usually stouter branches and branchlets, and by the elliptical bodies of the large samaras.

The limits of the distribution of *Fraxinus Biltmoreana*, as now shown by specimens preserved in the herbarium, extend from the mountains of North Carolina (Biltmore herbarium, no. 4049, Biltmore, N. C., type locality), to northern Georgia (Dr. J. K. Small, near Toccoa, Habersham county, Ga.). It is very probable that the species will be found to occupy a much larger area when better known.

DISPORUM MACULATUM (Buckley) Britton, Bull. Torr. Club **15**: 188. 1888.—Splendid examples of this rare species were collected on the slopes of Busbee mountain, Buncombe county, North Carolina, April 22, 1896, the blossoms just opening; and again, April 27, 1897, specimens with flowers fully expanded were gathered at Hot springs, Madison county, North Carolina. In these specimens, as well as in a mere fragment preserved in the Chapman herbarium from the latter locality and gathered in 1887, the stamens are longer than the segments of the perianth, the divisions of which are liberally sprinkled with small purplish dots, and the ovary is conspicuously white-woolly. The pubescence of the stems and leaves is coarser, and not so dense

as on *D. lanuginosum* (Michx.) Nicholson, with which it not infrequently associates.

AMORPHA VIRGATA Small, Bull. Torr. Club **21**: 17. 1894.— In the mountains of western North Carolina *Amorpha virgata* is frequently represented, and, so far as I am aware, is the only species of the genus in the upland section of the state. It is found in considerable patches at elevations of 700–1000^{m}, instances of which are located near Round knob, McDowell county, and Busbee mountain, Buncombe county, forming coarse but attractive shrubs 1–3^{m} high. The flowers appear at the stations given about the first of June, the fruit hanging until after the leaves have fallen.

Brauneria Tennesseensis, n. sp.—A hispid, perennial herb from a long and fusiform blackened root, 2–3^{dm} high, bearing showy heads of purplish flowers in late summer: stems 1–several from the top of the root, simple or with one or two primary branches, papillose-hispid: leaves linear to linear-lanceolate, 0.5–1.75^{dm} long including the petiole, 0.5–1^{cm} broad, attenuate at the base, the apex usually acute, 3-nerved, papillose-hispid, especially along the margins: peduncle thickened upwards, sulcate angled, like the stem or more sparingly hispid, usually bearing one or two leaf-like bracts: heads 1.5–2^{cm} high, conical, nearly as broad as high: involucre composed of lanceolate ciliate scales, thickened at the base: rays 2–3^{cm} long, purplish, hispid on the lower surface, 2-cleft at the apex, the divisions mucronate: chaff rigid, carinate, pointed, longer than the disk flowers: achenes 4-sided, wing-angled on the longest side: pappus a narrow-toothed border with four prominent points corresponding with the angles of the achene.

Collected Aug. 19, 1897, just in flower, on a dry, gravelly hill near LaVergne, Tenn., and associated with *Grindelia lanceolata* Nutt.

B. Tennesseensis is closely related to *B. pallida* (Nutt.) Britton, from which it may be known by its smaller size, very hispid stems and leaves, longer and narrower achenes (which are prominently winged on the longest angle), by the later season of flowering, and the spreading scarcely drooping rays.

SOLIDAGO ULIGINOSA Nutt. Jour. Acad. Philad. **7**: 101. 1834.— Dr. Gray[1] pointed out that Nuttall probably had more than one plant in view when he described the above, and that there can be no doubt as

[1]Proc. Am. Acad. **17**: 193. 1882.

to the one upon which the species was founded. As qualified in the *Synoptical Flora*,[2] *S. uliginosa* finds its southern limits in the mountains of Pennsylvania, but specimens that match northern material passing under this name were collected September 15, 1897, in the mountains of Macon county, North Carolina, at an elevation of about 1500^{m}. In this situation the plants were found close to the sides of the waterways that under ordinary conditions are kept moist by the liberal and usually evenly distributed precipitations. I am indebted to Dr. Small, of Columbia University, for much help and information regarding this material.

CRATÆGUS TOMENTOSA **Chapmani,** nom. nov.— *Cratægus tomentosa microcarpa* Chapm. Flora, ed. 3. 139. 1897. Not *C. microcarpa* Lindl.— So far I have not seen the typical *C. tomentosa* in the south, and I agree with Dr. Chapman in recognizing the form with very small fruit as a well marked variety. Near Biltmore, N. C., *C. tomentosa Chapmani* forms a small tree 4–6^{m} high, growing usually in rich soil and attaining a trunk diameter of 1^{dm} or less. The branches are gray, and armed with slender spines: leaves 5–12^{cm} long (occasionally larger), broadly ovate, prominently veined, sharply serrate and incisely lobed, and from sparingly to densely pubescent beneath: corymbs many-flowered, leafy, bearing glandular, caducous bracts, and covered when young with fine, pale tomentum, which finally disappears: flowers small, 1.5^{cm} wide, ill-scented: calyx pubescent, the divisions lanceolate, serrate, acute: fruit sub-globose, 5–7^{mm} in diameter at maturity, bright red, long persistent.

Originally discovered on the banks of Silver creek, Floyd county, Georgia, by Dr. Chapman, whose name I have used in the new trinomial. The distribution is probably confined to the region of the southern Allegheny mountains.

CAREX OLIGOCARPA Schk. Riedg. Nachtr. 58. *f. 170.* 1806.— On May 26, 1896, in sandy soil bordering the Swannanoa river at Biltmore, N. C., material that matches specimens of *C. oligocarpa* from Vermont and Delaware was found in frequent patches. Dr. Chapman[3] admitted the species to the range of his work on the authority of M. A. Curtis, but I cannot at this time find any further notice of its distribution in the south.

[2] Syn. Flora 1^{2}: 151. 1884.

[3] Flora S. U. S. ed. 2. suppl. 661. 1889.

CAREX JUNCEA Willd. Enum. Pl. Hort. Berol. Suppl. 63. 1809.—Specimens from Roan mountain, Mitchell county, North Carolina, are frequently displayed in herbaria and the handbooks treating on the flora record no other stations, although Boott[4] extends the range to the mountains of North Carolina and Georgia. At the summit of Craggy mountain (2000^{m} elevation), Buncombe county, North Carolina, *Carex juncea* was found in abundance July 13, 1897, growing in dense tufts from the black, fertile soil characteristic of the high elevations of the region.—C. D. BEADLE, *Biltmore, N. C.*

[4] Ill. Gen. Carex 189. 1867.

OPEN LETTERS.

A MEXICAN TROPICAL BOTANIC STATION.

THE BOTANICAL GAZETTE during the past three years has agitated in its editorial columns and by the publication of open letters the establishment of a tropical botanical laboratory. The consensus of opinion seems to be that such a laboratory should be situated in Jamaica, which would be easily accessible both to English and American botanists. Jamaica has, without a doubt, many advantages over other localities in the western tropics. The late Professor J. E. Humphrey in a letter to the GAZETTE refers to the peculiar conditions which make Jamaica a suitable place for such a laboratory:

> As compared with many other parts of the tropics, the climate of Jamaica is exceptionally healthful, and it is remarkably free from poisonous animals. Its continental character makes possible a rich and varied flora, and within a few miles one may pass from the sea level to the summit of the Blue mountains, 7360 feet high. The island is a British colony, which means that life and property are secure, the roads fine, the language English. It is accessible by steamer at least once a week from either Boston, New York, Philadelphia, or Baltimore, and the principal points are now connected by railroad. There are on the island two interesting botanic gardens at Castleton and Gordon Town under the direction of Mr. Wm. Fawcett, Director of Public Gardens and Plantations, who would doubtless give such an enterprise every encouragement and much valuable aid.

All these advantages seem to point to Jamaica as the most suitable place for the establishment of such a tropical laboratory, where much needed botanical research can be prosecuted. Professor Goebel is quoted in the GAZETTE[1] as saying:

> It appears to me particularly desirable that the laboratory should be placed near a botanical garden, because of the greater number of plant forms available, besides the herbarium and library, as well as the opportunities for experimental culture afforded. Furthermore, another important condition would be the location of the laboratory as near as possible to the primitive forest.

However great the advantages of Jamaica may be for the study of tropical vegetation, it is advisable not to overlook other regions of the western hemisphere which are especially suitable for the botanical investigations which alone can be carried on in a tropical country. The writer wishes to make a plea for Mexico, not because he does not recognize the suitability of Jamaica, but

[1] **23**: 208. 1897.

because he desires to call the attention of American and English botanists to several Mexican localities with which he is personally familiar, having visited them in the summer of 1896.

Orizaba.—Orizaba is a town of 15,000 inhabitants in the state of Vera Cruz, on the line of the Mexican railway, 82 miles from Vera Cruz, 181 miles from the City of Mexico, at an elevation of 4000 feet above the level of the sea. The town lies in a little valley surrounded by very fine mountains. The peak of Orizaba (17,356ft), however, cannot be seen from the town, although within a half day's journey. The town is composed for the most part of low houses with red tiled roofs; it is crossed by two small streams and by the little river Orizaba (through a rocky ravine filled with tropical plants), all of which unite near by in the river Blanco. The region is especially rich in tropical orchids and epiphytes. The city is in close proximity to the *tierra caliente*, the *tierra templada*, and, on the sides of Mount Orizaba, to the *tierra fria*. A tramway extends from the station into the town, passing the doors of the hotels; another line extends to the pretty suburb Yngenio, and thence a little beyond to the Nogales station on the Mexican railroad. Of superb beauty and grandeur, affording fine botanizing ground, is the cañon of the Rincon Grande about three miles out of the town. Orizaba and the neighboring town of Cordoba (2000ft) are easily reached by the Mexican railway from Vera Cruz after three hours' ride through grand and inspiring mountain scenery. Botanists from the central and eastern United States can reach Vera Cruz by steamer direct from New York, New Orleans, and Galveston. Botanists from the Pacific coast and from the Rocky mountain region can take the overland route from El Paso to the City of Mexico, and thence to Orizaba, passing across the interesting Mexican deserts and descending step by step from the elevated Mexican tableland in the *tierra templada* to Cordoba in the *tierra caliente*.

Jalapa.— Jalapa, reached from Vera Cruz and from the City of Mexico, also presents exceptional advantages for tropical botanical research.

It is, however, to neither of these places that the writer wishes to advert especially. It is to the little known and interesting region tributary to the town and seaport of Tampico on the Gulf coast. Tampico is too unhealthy for the establishment of a station there, although the region is of exceptional interest with the river Panuco and the Lago de Tamiahua giving access by canoes to the luxuriant tropical forest of the Gulf coast. If such a laboratory be established, it must be at sufficient elevation to have a salubrious climate. Such a place is found at a station on the Mexican Central railroad called Las Canoas, 144 miles distant from Tampico.

Las Canoas.— Las Canoas is situated in the beautiful basin-shaped valley of that name (3500ft above sea level). The soil is a red clayey loam, and a stream, having its rise in a perennial spring, affords an abundant supply of

clear and limpid water. Good water is a very important item to strangers in a tropical country, especially in Mexico, where the streams are polluted by the frequent washing of clothes along their courses. The Valley of Las Canoas is shut in from the surrounding country by high hills, and is especially well situated for the establishment of a tropical laboratory. The air is clear and bracing, and food is easily obtained. Easy of access to the deserts on the table land above by the daily trains which run on the Mexican Central railroad to San Luis Potosi and thence to Aguas Calientes, the locality is especially well situated for botanizing. From Las Canoas by means of the railroad toboggan, or by train, one can descend through the grand and impressive Tamasopo cañon into the tropics. Mr. Pringle[2] has described the characters of the region in such an interesting pen picture, that the writer cannot refrain from quoting him at this point:

> Gliding beside the stream of purest water issuing from the hillside cave, the train advances cautiously to the gate of the cañon cut out by the river formed by the stream which issues from the perennial spring uniting with another stream which rushes down through a wild and deep barranca behind the small village of Las Canoas. It enters above plunging, boiling waters. Then for eight or nine miles the roadbed has been cut in the rock of the steep mountain side, or has been laid on walls which spring from far below. On such dizzy heights the train hangs and sways and winds through constantly occurring curves. Where mountain buttresses interpose, tunnels open a way, till eight are passed. Within the cañon long vistas of the wildest mountain scenery open before us. The opposite mountain side is precipitous in places, in others cut by gorges. It is everywhere covered with a variety of trees, except here and there on the steeps near the summit, where some Indian has built his hut and cleared a plot for corn or bananas. From our perch, still high on the mountain, we are looking down upon a fertile hacienda, on broad open valleys stretching among low hills, which are covered with heavy tropical forests, on meadows with grazing herds, and on broad fields of corn and cane. In making the descent from the mountain side to Tamasopo siding, the road turns back upon itself in several long loops. At the foot of the mountain it passes through a heavy forest in whose shade is a coffee plantation. The region is in the one of heaviest rainfall. The winds, heavily laden with moisture which arises from the Gulf, are repelled from the heated lowlands, to precipitate on these mountains torrents of rain, as their temperature is lowered by their ascending into cooler regions of air. Yet the temperature of Tamasopo, though a little lower than that of the coast, is still a tropical heat; and from conditions of so great heat and moisture results a vegetation of great luxuriance. The forests, composed of numerous species, are thick, the undergrowth beneath them is dense, and trees and shrubs are bound together by clambering vines to form an almost impenetrable jungle. Each large tree, with huge spreading branches and leaning trunk, it may be, becomes a garden of plants. On its rough mossy surface root ferns, orchids, bromeliads, and cactuses; and lifted thus into the air and light they thrive apace. The most abundant tree of these tropical forests is doubtless a fig, *Ficus Segoviae*, with smooth gray bark, and often of vast size, especially when growing

[2] Garden and Forest **6**: 182, 203. 1893.

beside streams. It is upon the fruit of this and other wild figs that pigs, peccaries, and monkeys, largely subsist. The most common oak here is *Quercus Germana*, which bears acorns two inches long. *Dendropanax arboreus*, symmetrical in form, and bearing attractive foliage and fruits, is one of the most interesting trees here; and *Banara Mexicana* is pretty when covered with white berries. From Tamasopo to the station at Rascon, where a good restaurant is kept, the road threads valleys and runs between wooded hills and a river bank. The clear blue water shows through gaps of the thickets covering the river banks, and here we first see clumps of a giant bamboo, in each clump five to ten stalks, every stalk four to six inches thick, a gracefully spreading plume twenty to forty feet high. Scattered palm trees soon appear, and as we near Rascon we are running through a forest of palms, straight, slender shafts, thirty feet high, bearing heads of broad leaves. Beyond Rascon, as far as Micos, are more palm forests and bamboos, and rivers and swamps and jungles, alternating with open meadows, which lead back between hills whose sides are covered with oaks. Meadows and glades and mountain tops — all are deer parks; and the Mexican tiger, the puma, prowls through the less frequented wilds of all this region.

On every hand is rich and inviting botanizing ground in an unbroken virgin forest.

Las Canoas is reached from Tampico on the Gulf coast. Tampico is reached by line of steamers from Galveston, New Orleans, New York, and European ports. Leaving Tampico at 6:00 A.M., Rascon (116 miles distant) is reached at 11:20 A.M.; Las Canoas, 144 miles distant from Tampico, at 1:35 P.M.; and Cardenas, where the mountain engines are taken off, at an elevation of 4500 feet, 158 miles distant, at 2:20 P.M. From Rascon to Cardenas (42 miles) an ascent is made of 3500 feet. The Tampico branch of the Mexican Central railroad, passing through San Luis Potosi, makes connection with the main line at Chicalote. The region tributary to this line from Tampico to San Luis Potosi has been visited by Mr. C. G. Pringle, so that American and European herbaria are well supplied with the representative plants of the region.

No more inviting district is within easy access of the American botanist than this one, tributary to the Tampico branch of the Mexican Central railroad. A temporary station could be established here at very little expense and the virgin forest would supply enough botanical material for years to come.— JOHN W. HARSHBERGER, *University of Pennsylvania*.

CURRENT LITERATURE.

BOOK REVIEWS.

Cyanophyceæ and bacteria.

DR. ALFRED FISCHER has made further investigations into the structure of the Cyanophyceæ and bacteria.[1] He admits that Bütschli's central body cannot be explained as contracted cell contents, but insists that there is no such sharp line between central body and "Rindenschicht" as Bütschli figures. The analytical value of staining is thoroughly discussed. The author stained substances of known chemical composition, and came to the conclusion that the coloring does not depend upon a chemical union between the stain and the tissue elements, but is rather a physical phenomenon and does not determine the relationships of albuminoid bodies or the morphological values of cell elements. Fischer claims that Bütschli was mistaken in the assumption that digestion experiments support the theory that the central body is a nucleus. The green rind of the cyanophyceous cell is a genuine chromatophore and can be isolated by reagents. He was not able to demonstrate a layer of protoplasm between the chromatophore and cell wall, but believes that plasmolytic phenomena and the collecting of granules along the cross walls indicate such a layer. The ground mass of the central body is nothing but the principal part of the protoplast which is surrounded by the chromatophore. Very often the ground mass stains only slightly deeper than the chromatophore and cannot be compared with a nuclear network. The ground mass of the central body does not take any part as an independent organ either in cell division or in spore formation. Nor do the granules play any characteristic part during division. In short, there is no nucleus or organ which resembles a nucleus in the Cyanophyceæ, nor is the central body a phylogenetic forerunner of the nucleus of higher forms.

In treating of the sulfur bacteria it is found that, contrary to Bütschli's description, there is no colored rind and colorless central body in Chromatium, but the coloring material is uniformly distributed. Consequently there can be no comparison with the Cyanophyceæ in this respect. Among the sulfur bacteria the central body is found only in individuals which are free from sulfur, and in sulfur-free Chromatium a central body cannot be

[1] FISCHER, ALFRED.—Untersuchungen über den Bau der Cyanophyceen u. Bakterien. 8vo. pp. —. Jena: G. Fischer. 1897. *M.* 7.

demonstrated. There are granules in Chromatium and in Beggiatoa which stain red with haematoxylin, but they cannot be called chromatin on such evidence. There are no genuine nuclei in the sulfur bacteria.

In dealing with the genuine bacteria, the theory that bacteria are nuclei without cytoplasm is regarded as unfounded. After the best fixing agents neither Spirillum nor other bacteria show clear, less deeply staining ends. Bütschli's central body is nothing but the entire protoplast contracted by the plasmolysis of preparation. The contents of the bacterium cell consist of a lining of protoplasm along the wall and a central cavity which in elongated forms is chambered by protoplasmic septa. Present methods fail to demonstrate a nucleus. The more deeply staining granules are not nuclei, or chromatin granules. The relationship of the sulfur bacteria and all other bacteria to the Cyanophyceæ is merely one of loose, superficial morphology. They stand in closer relation to the Flagellatae.

Microtome sections from paraffine material were stained in the most approved manner, and the technique throughout was thoroughly up to date. The plates are exceptionally elegant, aud doubtless show what there is to be seen.—CHAS. J. CHAMBERLAIN.

A laboratory manual.[2]

SUCH is the name given to a little book by Principal Charles H. Clark, of Windsor Hall School. It seems to be the author's idea to furnish a large amount of suggestive material, from which work may be obtained either for elementary or more advanced courses; and he follows, as he states, "the lines suggested in the Report of the Committee of Ten." As the reviewer prepared the botanical part of that report, it was a matter of interest to him, not to say surprise, to see it take this expression. It has never fallen to our lot to be so puzzled by a schoolbook dealing with botany. It is a puzzle both as to its botany and as to its pedagogy. It claims to be adapted for use in elementary courses, but there is no adequate explanation of the terms used or of the structures or functions to which they apply; the terminology is utterly confusing and inconsistent; and there is no morphological thread whatsoever upon which the facts may be strung.

The author seems to have obtained a multitude of facts, but they are as incoherent as a sand bank; and what is worse, the essential structures are most frequently omitted. This is notably true in the treatment of the spermatophytes, where the morphologically important structures of the lower groups are entirely dropped, and the work is confined to the histology of the

[2] CLARK, CHARLES H.—A laboratory manual in practical botany. Small 8vo. pp. 271. *figs. 191*. New York, Cincinnati, Chicago: American Book Company. 96 cents.

sporophyte, and a little of its physiology. Such guidance may teach laboratory methods, may collect a mass of unrelated facts without any reference to their importance; but it never can result in a clear conception of plants.

A good teacher can manage to get along with a lot of poorly digested material, although it is an unnecessary burden, but misrepresentation is unpardonable. We do not have space to quote the many remarkable statements noted in a casual reading of this book, but we must justify our strictures by presenting a few.

The form of the plant (thallophyte) which bears simple spores is known as the *sporophyte* (p. 9).

The male gamete (in spermatophytes) is either the original nucleated protoplasm of the pollen grain, or is one of the nucleated cells formed by the division of that protoplasm in the formation of the male prothallium in a tube which grows out of the pollen grains (p. 11).

Seeds, in the higher plants, result from the fertilization of ovules by pollen grains. Seeds grow directly into ordinary plants when the conditions are favorable. Spores result from cell division. They contain no embryo and do not grow into ordinary plants (p. 36).

In the cells of certain modified leaves of this cluster (in mosses) minute antherozoids are borne (p. 38).

The oospore is raised up above the top of the female plant by a very slender stalk, the seta, and develops there into the sporophyte form of the plant (p. 38).

The enlarged top that develops on the female plant (in mosses) is a sporangium (p. 38).

No sexual reproduction is known to occur in this class (schizophytes). There is consequently no alternation of generations from sporophyte to gametophyte. The plant is the sporophyte (p. 59).

A zygospore is thus produced (in Spirogyra) that becomes encysted and falls to the bottom of the water, where, imbedded in the mud, it preserves the life of the plant until the next season. On the return of spring, the zygospore grows in the asexual way into a new filament. This is gonidial reproduction (p. 98).

Male gametes (in lichens), *spermatia*, conjugate with female gametes, *trichogynes*, inside the tissues of the hyphæ (p. 145).

A spore fruit results (in liverworts), and the spores develop by fission of cells into small and simple growths called *protonemæ*, from which new plants arise (p. 169).

Mosses are reproduced asexually by different modes of budding, but not, so far as is known, by asexual spores (p. 176).

The capsules (in mosses) containing the egg cells become filled with spores that closely resemble the asexual spores of some other plants (p. 177).

From this fact that their structure is wholly cellular, the plants of the preceding subdivisions are called *cellular cryptogams* (p. 183).

When the spores germinate (in pteridophytes), there is first formed a protonema which develops into a small thalloid leaf called *prothallium* (p. 185).

If the under side of one of these heart-shaped prothallia be examined under the microscope, special differentiations of the cells will be found near the sinus of the heart; these are the *archegonia* or *pistillidia;* they are rounded aggregations of cells,

with a large centrally situated cell that divides into two. Of these two cells, the lower develops into the egg cell, or oosphere; the upper develops into a tube which becomes filled with a mucilaginous substance that is afterwards discharged, leaving the passage to the oosphere open.

More distant from the sinus of the prothallium are the *antheridia*, situated among the root hairs. In these spirally coiled antherozoids are developed, being finally discharged by the rupture of the cell wall. Accompanying each antherozoid is a small cell, the use of which is not understood. Each antherozoid is provided with cilia, by means of which it swims about when the prothallium is wet. It may in this way pass to other prothallia, where, by fertilizing the oosphere, a hybrid variety is produced (p. 185).

Two groups of plants included here are *heterosporous*, *i. e.*, they have two kinds of spores, female macrospores and male microspores (p. 186).

The plant is the sporophyte (the spermatophytes). There are two kinds of spores, microspores or pollen grains, and macrospores borne in embryo sacs (p. 205).

The feature that especially distinguishes the spermaphytes from the plants of the seven preceding subdivisions is the production of true seeds, which are the result of the fertilization of the embryo cell by the receipt of the contents of the pollen cell. The embryo cell is borne in a pistil (p. 206).

The ovules are borne in closed cavities, the *ovaries*, at the base of *pistils*, which are modified leaves; the pollen cells are borne in anthers raised on stamens; which are also modified leaves (p. 218).

The contents of the pollen grain now mingle with those of the embryo sac, and the life of the seed commences (p. 219).

Some plants develop their leaves alternately; others develop them in pairs. From these facts have arisen a division of the angiosperms (into monocotyls and dicotyls) (p. 220).

The above quotations need no comment, and could some of the illustrations be reproduced the same remark would be appropriate, although some well-known and classic illustrations help the general average.—J. M. C.

Essays on plant life.

POPULAR books about plants are few. Accurate and interesting books about plants are rare indeed. We justly welcome, therefore, a book, embodying these qualities, which has lately been issued by Dr. J. C. Arthur of Purdue University and Dr. D. T. McDougal of the University of Minnesota.[3] It consists of twelve essays, selected in equal numbers by the two authors from popular addresses and articles presented within the last few years. These have been more or less modified to adapt them to each other and to current botanical knowledge. It will not be amiss to quote the titles of the essays to indicate in a measure the compass of the book.

[3] ARTHUR, J. C., and MACDOUGAL, D. T.—Living plants and their properties; a collection of essays. Small 8vo., pp. x + 234. *figs. 28.* New York; Baker & Taylor. Minneapolis: Morris & Wilson. 1898.

The six by Dr. Arthur are: The special senses of plants; Wild lettuce as weed and compass plant; Universality of consciousness and pain; Two opposing factors of increase; The right to live; Distinction between plants and animals.

The six by Dr. McDougal are: The development of irritability; Mimosa, a typical sensitive plant; How cold affects plants; Chlorophyll and growth; Leaves in spring, summer, and autumn; The significance of color.

Into a detailed examination of the essays we cannot go. All are well written and interesting. Dr. McDougal's deal chiefly with important facts of plant activity, while Dr. Arthur's are inclined to be more speculative and philosophical. The latter, therefore, offer the greatest opportunity for criticism. Few will be able to concede the correctness of the author's definitions and premises in the essay on the Universality of consciousness and pain, wherein he seeks to maintain the thesis that "all living organisms, whether animal or plant, are capable of conscious pain to a degree commensurate with the requirements of their nature." Indeed, he seems to destroy his own argument by concessions. For at the outset he excludes from consciousness, as he uses it, all idea of self-consciousness, which, he adds, "is necessary that the individual may, for instance, be aware of its own identity" (p. 65). Later he says: " . . . when the organism is aware of a feeling of pleasure or pain, or of any other sensation, *knowing that the same is located within its own organs*, it is possessed of consciousness" (p. 71).

Nor can we believe that Dr. Arthur has really found in the "carbohydrous investment" of plants, and the "nitrogenous investment" of animals, a "crucial test" for distinguishing them. Who can accept a criterion which, the author says, excludes the Olpidiaceæ and the Synchytriaceæ from the rest of the Chytridineæ? Does not the argument "it is known with much certainty that they have no cellulose envelope; they are, therefore, not plants, and must, in consequence, be animals," beg the whole question?

It is a pity that the book should be so poorly manufactured. Bad proof-reading and a "countrified" binding, spoiling the artistic cover design, show the novice hand of the Minneapolis firm which did the mechanical part. The work of the authors deserves a better setting. The book may well find a place in public and school libraries, and is commended for popular reading.—C. R. B.

The phytogeography of Nebraska.[4]

THIS is a distinct and noteworthy addition to the ecological plant geography of this country. It is a general survey, the first of a series of install-

[4] POUND, ROSCOE and CLEMENTS, FREDERIC E. — The phytogeography of Nebraska. I. General Survey. 8vo., pp. xxi + 330. Lincoln, Nebraska: Jacob North & Co. 1898.

ments dealing with the floral covering of Nebraska from the phytogeographic standpoint. The authors follow very largely the methods of Drude, especially as outlined in his *Pflanzengeographie von Deutschland.*

The introduction discusses the relation between phytogeography and biology, and gives an interesting history of the investigation of the Nebraska flora. The first chapter is introductory, dealing with the physiognomy and climatology of the state. The second chapter is entitled "Statistic and regional limitation," and after the enunciation of certain general principles there is to be found a characterization of the four regions into which the authors subdivide the state: the wooded bluff and meadow land, prairie, sand-hill and foothill regions. Then follow lists of species in which these regions agree and differ. The third chapter, the "Vegetation forms of the flora," is of great interest. The authors at this point depart somewhat from Drude's classification, but such departure seems almost inevitable in view of the great difference between the life conditions in Germany and Nebraska. The main subdivisions are into woody plants, half-shrubs, pleiocyclic herbs, hapaxanthous herbs, water plants, hysterophytes, thallophytes. These groups are quite intimately subdivided, especially the pleiocyclic herbs and thallophytes. The next chapter has to do with the "Ecological and biological relations of the natural groups." The pteridophytes and spermatophytes are discussed in successive groups with regard to habitat, or as Warming would say, they are referred to their respective plant societies. The fifth and last chapter treats of the "Plant formations of the state." These are quite fully treated and are, of course, full of interest to plant geographers. Perhaps the most distinctive formations are those of the sand hills, with their bunch grasses, blow outs, and sand draws; and of the foothills, with their undershrubs, mats, and rosettes.

Inasmuch as this is the pioneer work of its kind in America, the task of its authors was peculiarly difficult. Questions of terminology in ecological plant geography are of no easy settlement because the field is so very new, and the transference of German classifications and technical terms to American soil involves great difficulty, just as the correlation of European and American geological strata caused confusion when the attempt was first made. The adverse criticisms suggested by a hasty perusal have to do largely with terminology, and hence are not of the most vital importance. There seems to be, for example, a strong tendency to use Greek derivatives in place of the simpler and more expressive English equivalents. The extension of the term "thallophyte" to include mosses and liverworts seems very objectionable, not only because the term has been long preempted by morphologists, but because there is a radical ecological distinction between the true thallus and the moss gametophyte. The rejection of Warming's term mesophyte is very questionable, since it involves the introduction of several new terms and destroys the unity of the classification; a subdivision

of the mesophytes into forest, grass, and waste societies would serve the authors' purpose fully as well.

It may be too early as yet to predict whether the direction to future work in plant geography will be given by Warming or by Drude; and so whether we shall speak of ecology or phytogeography, of life forms or of vegetation forms, of plant societies or formations, is yet to be decided. Perhaps the solution will be by a division of labor, phytogeography including the larger problems of distribution and dealing with extensive formations, while ecology will have to do more with local and habitat relations, including anatomical as well as field investigation. In any event, the *Phytogeography of Nebraska* will be an indispensable work to all American students along either line.— HENRY C. COWLES.

MINOR NOTICES.

IT IS A PLEASURE to record the publication of an English translation of the admirable *Lehrbuch der Botanik*[5] by Strasburger, Noll, Schenck and Schimper, of the University of Bonn. This translation has been made by Dr. H. C. Porter, of the University of Pennsylvania, from the second German edition, which was noticed in this journal in August 1896. The publication has been long delayed (it was announced for last March), but this delay has doubtless been unavoidable, and it has certainly whetted desire. The translator has succeeded better than was to be expected in preserving the flavor of the original and at the same time putting it into idiomatic English. He has avoided introducing new terms, in rendering technical German ones, by adhering to the usage of previous translators. There may be some question of the wisdom of too slavish conformity, but it is at least an error on the side of safety. We are pleased also to announce that the publishers have decided to issue the book in two parts, the first containing the morphology and physiology, and the second the special morphology of cryptogams and phanerogams. When we add that the manufacture of the book leaves nothing to be desired (the imperfections of the color printing being entirely unimportant, as the figures themselves are) there is nothing more to be said.— C. R. B.

GARDEN-MAKING is attractive to many more people than know how to go at it, and garden-making would be undertaken by many more people if they had a proper mental picture of what a garden should be and knew how to go about realizing it. The last volume of the *Garden-craft series*, by Professor L. H. Bailey,[6] endeavors first to create the proper conception and then show how the picture can be painted in plants and soil.

[5] STRASBURGER, NOLL, SCHENCK and SCHIMPER.— A text-book of botany, translated from the German by H. C. Porter. 8vo. pp, x + 632. *figs. 594.* London & New York: The Macmillan Co. 1898. $4.50. In two volumes, each $2.50.

"This book understands the garden to be that part of the premises which is devoted to ornament, and to the growing of vegetables and fruits either for the home consumption or for market. The garden is, therefore, an ill-defined demesne; but the reader must not make the mistake of defining it by dimensions, for one may have a garden in a flower pot or on a thousand acres. In other words, this book believes that every bit of land which is not used for buildings, walks, drives, and fences, should be planted. What we shall plant — whether sward, lilacs, thistles, cabbages, pears, chrysanthemums, or potatoes — we shall talk about as we proceed."

And talk about it the author does, in the most interesting and attractive style, bringing forth out of the treasures of his experience and observation things new and old. In a hundred pages and more of general advice he tells the things which the novice most needs to know, and, if we mistake not, many things which the professional gardener would be profited by knowing. Then follows a discussion of the principles of landscape art as they apply to planting city yards, suburban grounds or rural estates. A third section is devoted to suggestions in regard to ornamental planting; a fourth to the fruit plantation, and another to the vegetable garden. In fact there is no one who owns the land on which he lives who would not find in this book something of profit and interest.—C. R. B.

THE ANNUAL REPORT of Mr. Fawcett as director of the gardens of Jamaica contains many items of interest in connection with his recent description of gardens in this journal (Nov. 1897). During the year 264,000 plants were distributed from the Hope Gardens to planters and farmers, and to this total is to be added the specimens sent out from the other gardens, which are used as minor distributing centers. Cultural and acclimatization experiments of great value have been carried on, and the economic efficiency of the system of gardens is certainly many times in excess of the actual cost to the island government. Among the points of scientific interest presented in the report, it is noted that Bermuda lilies grown in Jamaica show a rapid multiplication of bulbs, with no resting period of any sort.

Although no systematic survey is in progress, seven new species of phanerogams and forty-four species of mosses were collected during the year by various members of the staff.—D. T. MCDOUGAL.

NOTES FOR STUDENTS.

MESSRS. HITCHCOCK AND CLOTHIER have made a report upon the vegetative propagation of the perennial weeds of Kansas.[7] In it is contained an

[6] BAILEY, L. H.— Garden-making: suggestions for the utilizing of home grounds. Aided by L. R. Taft, F. A. Waugh, and Ernest Walker. 12mo., pp. viii + 417, *figs. 256*. New York: The Macmillan Co., 1898. $1.

[7] Bull. 76, Feb. 1898, Experiment Station of the Kansas State Agricultural College.

exhaustive list of the common weeds, grouping them as follows: those which propagate by creeping roots, by creeping stems, or by forming "crowns." A summary is made of a number of experiments upon weeds with exceptional powers of vegetative reproduction. One of the most striking results was in the case of *Enslenia alba*, the climbing milkweed. Ten one-inch pieces of the root stock were planted ten inches below the surface, and seven of these sprouted. The immediately practical value of the report is found in the methods suggested for killing perennial weeds, and in illustrated descriptions of the underground parts of forty-eight of the commonest vegetable pests.—J. G. COULTER.

DR. DOUGLAS H. CAMPBELL,[8] in continuing his studies among the lower monocotyledons, has investigated the peculiar and monotypic *Lilæa subulata*, a characteristic Pacific coast form, ranging from Oregon to southern South America. In some important respects the results confirm those already obtained by the author in his investigation of Naias and Zannichellia, such as the cauline origin of both microsporangia and megasporangia, and the plerome origin of the sporogenous tissue of the stamen. This departure from the ordinary hypodermal origin of this tissue is noteworthy. The usual indefiniteness of the tapetum was also observed, one or two layers of wall cells and certain sterile sporogenous cells functioning as such. Just what the "tapetum proper" is it would be difficult to say.

The development of the megaspore presented no unusual characters, but the meager preparations did not permit a clear statement. There is enough variation in these structures to demand multiplied preparations before conclusions can be regarded as safe. The antipodal cells are not of the evanescent type, but organize into vigorous cells. A remarkable exceptional condition was the occurrence of a mass of tissue in the micropylar end of the embryo sac, replacing the egg-apparatus. Just what this signifies it is hard to say. Of course, we should be pleased to discover some certain evidence of the occurrence of nutritive tissue in the embryo sac of angiosperms before fertilization, and especially in the micropylar region, and every such observation as the above stimulates our expectation.

Perhaps the most unexpected result is the peculiar relation of the primary root apex to the axis of the embryo. Instead of lying in the axis of the terminal cotyledon towards the suspensor, it is directed to one side, almost continuing the axis of the lateral stem apex. The author regards this as a lateral origin of the root, and remarks that it is suggestive of the root of Isoetes, the basal segments of the embryo and the suspensor being possibly the equivalents of the "foot" of pteridophytes.

The author again finds that the primary suspensor cell does not divide, and that the embryo is derived entirely from the terminal cell resulting from

[8] Annals of Botany **12**: 1–28. 1898.

the first division. This is certainly different from most dicotyledons studied, and does not hold for Lilium, but it may be quite a constant feature among the more primitive monocotyledons.

It is a satisfaction to note that these investigations are confirming the growing belief that many of the so-called "reduced" forms are rather primitive forms.—J. M. C.

BY ISOLATING another form from the river Thames, Professor H. Marshall Ward[9] has made an addition to our list of violet-pigment bacteria. The form is somewhat polymorphic. When in favorable culture media, the bacterium may appear in the form of a filament 50–60μ in length, though it is usually a bacillus. When in adverse cultural environment it may be reduced to the micrococcus type. It is motile, being very actively so in the case of the bacilli of medium length. No spores are formed, unless the micrococcus forms be considered such, and they do not show the characters of true spores. The bacterium is not pathogenic for guinea pigs.

In all ordinary culture media the bacillus develops abundant growths. On gelatin plates the contour of the colonies is very similar to that of *Bacillus typhosus*, but as they become older those near the surface break through as small cones in a way very different from the typhoid colonies.

At about ten days' growth liquefaction begins, and at this time the superficial colonies begin to show a slight formation of the violet pigment which darkens slowly, and after several days becomes as dark in color "as a strong solution of gentian violet." By means of several culture media it was shown that the pigment is in the living zooglea mass, and not mixed with the active bacilli beneath the mass. Microscopical examination failed to demonstrate the existence of the pigment within the bacterial cells, but indicates that it exists external to the cell-walls which compose the zooglea matrix. The pigment is slightly soluble in water and readily so in alcohol.

There have been at least a dozen other descriptions of violet-pigment bacteria, and the opinion has prevailed among bacteriologists that when the life-histories are carefully worked out, several or perhaps all of the forms described may be reduced to a single type. The bacillus here described, however, seems to have characters which make it distinctly different from those previously described.— OTIS W. CALDWELL.

ITEMS OF TAXONOMIC interest are as follows: A. A. Eaton[10] has described a new Isoetes (*I. minima*) from Washington, being trilobed and with partial velum, as well as the smallest American species. W. N. Suksdorf[11] has published a key to the species of Plectritis and Aligera, the former with nine

[9] Annals of Botany **12**: 59. 1898.
[10] Fern Bulletin **6**: 30. 1898.
[11] Erythea **6**: 21–24. 1898.

species, the latter with ten, one of which is new. George V. Nash[12] has published a new genus of grasses, *Blepharoneuron*, a monotypic genus based upon *Vilfa tricholepis* Torr. G. N. Best[13] has described a new genus of mosses, *Fabroleskea*, based upon *Leskea Austini* Sulliv. Edward L. Greene[14] has described several new species of Compositæ from a collection made by E. O. Wooton in southeastern New Mexico, among which is a new genus, *Wootonia*, "about equally allied to Bidens and Cosmos." L. M. Underwood[15] has published a discussion of *Selaginella rupestris* and its allies, in the course of which he describes six new species. John K. Small,[16] in continuing his descriptions of numerous new species from the southern United States, proposes a new genus of Paronychiaceæ, *Forcipella*, based upon *Siphonychia Rugelii* Chapm. E. O. Wooton[17] has described an interesting new rose from New Mexico, *R. stellata*, which is the second member of a hitherto monotypic section (MINUTIFOLIÆ) of the genus. Edward L. Greene,[18] in recent folios of *Pittonia*, has published as follows: Results of a study of the Macoun Canadian collection of the species of Antennaria, fifteen new species being described, to which are appended three other new species of the genus from the southwest; a new genus of the Senecionidæ, *Rainiera*, based upon *Prenanthes stricta* Greene (*Luina Piperi* Robinson, *Psacalium strictum* Greene); seven new species of Erigeron; the establishment of the genus *Microsteris*, based upon *Collomia gracilis* Dougl., from which six additional species are segregated; and the establishment of the genus *Gymnosteris*, based upon *Collomia nudicaulis* Hook. & Arn.— J. M. C.

EDWARD L. GREENE[19] calls attention to the occurrence of "parthenogenesis" in *Antennaria plantaginifolia*, as well as in some of the so-called cleistogamous flowers of Viola. Of course he only means the setting of seed without pollination, but the observation suggests a profitable subject of investigation for the morphologist. It is hardly likely that it is a case of parthenogenesis, for this has been disproved for all such claims for the higher plants, but it is always interesting to know the origin of the vegetatively developed embryos.— J. M. C.

CONSIDERABLE INFORMATION about the natural conditions of plant life and the extent of the vegetation in Alaska is embodied in a recent report to

[12] Bull. Torr. Bot. Club **25**: 88. 1898.
[13] Bull. Torr. Bot. Club **25**: 108. 1898.
[14] Bull. Torr. Bot. Club **25**: 117–124. *pl. 330–335*. 1898.
[15] Bull. Torr. Bot. Club **25**: 125–133. 1898.
[16] Bull. Torr. Bot. Club **25**: 134–151. 1898.
[17] Bull. Torr. Bot. Club **25**: 152–154. 1898.
[18] Pittonia **3**: 273–311. 1898.
[19] The Plant World **1**: 102. 1898.

Congress[20] regarding the desirability of establishing experiment stations in that region. In many places the soil is remarkably rich, and native grasses and associated plants attain uncommon stature. A list is given of over one hundred species of economic plants collected by Mr. Evans.—J. C. A.

A RECENT PAPER by W. West and G. S. West[21] presents many interesting facts concerning the habits, methods of reproduction and structure of the Conjugatae, together with an interesting diagram of possible phylogeny.

One is not apt to realize the extent of parthenogenesis and other means of non-sexual propagation that are present in this group of plants. Filaments may fragment, and resting cells or cysts may carry the species through unfavorable conditions, but the most interesting structures are the parthenogenetic spores called aplanospores. These are thick-walled reproductive cells, formed by the contraction of the protoplasm in a vegetative cell and the secretion around itself of a heavy membrane. That such structures are parthenogenetic spores is proved by their not infrequent occurrence side by side with zygospores in the same material. They have been observed in several species of Mougeotia, Zygnema, and Spirogyra, as well as among the desmids in Closterium, Spondylosium and Hyalotheca. There is, however, one genus, Gonatonema, that reproduces entirely through such non-sexual spores, and yet is so closely allied to Mougeotia that the filaments are not to be distinguished in the sterile condition. There can be no doubt of the close affinities between these two genera, although one has entirely given up the method of sexual reproduction.

The diagram of phylogeny places Mougeotia at the end of a long line of ascent, with Gonatonema as a degenerate offshoot, and Temnogametum as a side branch. Spirogyra and Zygnema with other allied genera occupy the tips of another distinct system of branches. The Desmidiaceæ are regarded as an offshoot and somewhat degenerate group from this second main branch, and are not connected directly with the unknown ancestral types.—BRADLEY MOORE DAVIS.

ARTHUR H. CHURCH[22] has investigated the polymorphy of *Cutleria multifida* (Grev.). This plant unfortunately is not found on our temperate coast, so that its interesting peculiarities cannot be very well known to American botanists. There are two plants, described as the genera Cutleria and Aglaozonia, that have long been suspected to be phases of a complicated life cycle, and this paper largely deals with this problem.

[20] TRUE, A. C.—A report to Congress on agriculture in Alaska, including reports by Walter H. Evans, Benton Killin, and Sheldon Jackson. Bulletin of Office of Exper. Stations, no. 48, pp. 36, *pl. 23*. 1898.

[21] Annals of Botany **12**: 29–58. *pls. 4* and *5*. 1898.

[22] Annals of Botany **12**: 75–109. *pls*, 7–9. 1898.

Cutleria is a delicate little plant of the Phæozoosporeæ, that commonly grows in quiet water at a depth of at least two fathoms below tide mark, and vegetates at a mean temperature of 16°. It is widely distributed along the coast of Europe and in the Mediterranean, but is a seasonal form, being quite sensitive to changes of temperature. Thus at Plymouth, England, it is a summer annual which disappears in October. Cutleria bears sexual organs that discharge biciliated gametes of two sizes which have been observed to conjugate, the smaller with the larger. But the sexuality apparently depends upon a narrow range of physical conditions, and when these conditions are not present the plant is parthenogenetic. Thus, although the process of fertilization has been observed at Naples by two investigators, Reinke and Falkenberg, parthenogenesis is known to be extensively present among these plants in the English Channel at the end of the summer. Perhaps the parthenogenesis is associated with a fall in temperature. Extensive experiments by various observers have proved that the oospheres of Cutleria, whether fertilized or developing parthenogenetically, produce young plants with undoubted Aglaozonia characters.

Aglaozonia is a perennial on the English coast, much coarser in histology and stronger constitutionally than Cutleria, for it can stand a range of temperature from less than 3° to more than 20°. It also grows in far more exposed situations than the latter plant. Church has been able to raise young plants from the zoospores of Aglaozonia, and these developed protonema-like creeping filaments that finally matured Cutleria antheridia. These may be regarded as "precociously developed" male plants. Thus experiment has connected back and forth into one life history the forms formerly known as Cutleria and Aglaozonia.

It is well to bear in mind how unsettled are the data in respect to sexuality among the Phæozoosporeæ at the present time. *Ectocarpus siliculosus* is one of the classical forms in which sexuality among these algæ was first announced. But Kuckuck believes that this species is constantly parthenogenetic at Kiel, and Reinhart has observed both the conjugation and direct germination of gametes. And again, extensive studies by Sauvageau upon several species of Ectocarpus indicate that motile cells usually considered as gametes germinate without difficulty.—BRADLEY MOORE DAVIS.

NEWS.

M. J. ISTVANFFY has been appointed Professor of Botany at the University of Koloszvar.

PROFESSOR E. ZACHARIAS has been appointed director of the botanical garden at Hamburg.

DR. EDUARD STRASBURGER has been elected a foreign member of the National Academy of Sciences.

M. O. MATTIROLO, of Bologne, has been appointed Professor of Botany and Director of the botanical gardens at Florence.

DR. R. A. HARPER, of Lake Forest University, has been appointed Professor of Botany at the University of Wisconsin, to succeed Dr. Charles R. Barnes.

DR. THOMAS W. KIRK, late chief conservator of the forests in New Zealand, and long a most indefatigable investigator of the flora of that island, is dead.

A RICH MERCHANT of Stockholm, M. F. Kempe, has given to the university about $40,000 to found a chair of "biological botany," to be occupied by Dr. A. Lundström.

PROFESSOR D. W. PENHALLOW has published as a reprint from the *Trans. Roy. Soc. Can.* an interesting "Review of Canadian Botany," extending from 1800 to 1895. The bibliography contains 470 titles.

DR. GINTL, of Prag, Bohemia, intends establishing a botanical exchange bureau in the autumn. Lichens, Hepaticæ, Musci, and Pteridophyta of Europe, and Spermatophyta of central Europe, will be offered.

DR. A. J. EWART, 33 Berkeley st., Liverpool, England, who has undertaken to translate Pfeffer's *Physiologie* into English, desires authors to send him a copy of their works that the literature may be cited to date.

M. EUGÈNE AUTRAN has published (*Bull Herb. Boiss.* **6**: 81–84. 1898) an interesting sketch of the botanical career of Nicolas Alboff, who at the time of his recent death was botanist for the Museum de la Plata, Argentine Republic. Alboff was practically the only botanist who had a personal acquaintance with the trans-Caucasian region of his native country, while his *Prodromus florae Colchicae* was the fruit of extended travel and collection

in Central Asia. He went from the Boissier Herbarium to South America in 1895, bound then upon a year of botanical exploration of Tierra del Fuego.

PROFESSOR W. W. BAILEY has succeeded in raising among his friends the sum of $1029 for the use of his department, with much more promised. The money was accompanied by messages appreciative of his long and faithful service.

DR. FRITZ NOLL, of the University of Bonn, on April 1 was appointed *etats-mässigen Professor* of Botany at the Royal Academy of Agriculture at Popplesdorf, to succeed Professor Dr. F. Körnicke, who has been nominated as privy councillor and retires from active service, but retains the direction of the economic section of the garden of the Academy. Dr. Noll retains his position in the University of Bonn.

THE COMING MEETING of the A. A. A. S. at Boston promises to be one of the most notable in the history of the association. It is the fiftieth anniversary, and special efforts are being made to arrange a worthy celebration. The local committees have been appointed, and the week selected is August 22 to 27. The local secretary is Professor H. W. Tyler, of the Massachusetts Institute of Technology. The usual number of affiliated societies will meet at the same time, among them the Botanical Society of America. The meetings will be held in the rooms of the Massachusetts Institute of Technology and of the Boston Society of Natural History, in three closely adjoining buildings.